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IMPLICATIONS OF PRESENT KNOWLEDGE AND PAST EXPERIENCE FOR A POSSIBLE FUTURE CHEMICAL/CONVENTIONAL CONFLICT

Gay M. Hammerman

Performed under subcontract for
INSTITUTE FOR DEFENSE ANALYSES

Historical Evaluation and Research Organization
A Division of Data Memory Systems, Incorporated
8316 Arlington Boulevard, Suite 400
Fairfax, VA 22031

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This report is based on papers presented at a CW conference in February 1984 to explore the "implications of present knowledge and past experience for a possible future chemical/ conventional conflict." The objective of the study was to stimulate new thought on the subject of possible future CW by involving as broad a group as possible. Three areas of research were

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pursued: the historical experience of past chemical combat; the nature of contemporary and anticipated chemical agents; and the weapons, equipment doctrine, and training which Soviet forces would bring to such warfare.

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8316 Arlington Boulevard, Suite 400
Fairfax, VA 22031

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FOREWORD

This study, which was conducted by the Historic Evaluation and Research Organization, was supported by the Institute for Defense Analyses as part of its overall research program in the area of chemical warfare.

This portion of the IDA research on CW is conducted in response to DoD task order MDA 903 84 C 0031: T-3-200 for the Deputy Assistant to the Secretary of Defense for Chemical Matters.

PREFACE

This report is part of a project carried out by the Historical Evaluation and Research Organization (HERO) for the Deputy Assistant to the Secretary of Defense (Chemical Matters), under subcontract from the Institute for Defense Analyses. The report is based on papers prepared on "Implications of Present Knowledge and Past Experience for a Possible Future Chemical/ Conventional Conflict" by two historians, two Sovietologists, and two scientists, and on the discussions of these papers at the In-Process Review meetings for the project, held February 2 and 3, 1984, at the HERO offices in Fairfax, Virginia.

The six papers are attached to the report as appendices. In accordance with the work statement for the project and with HERO's arrangements with the authors, no effort has been made to edit these papers into a consistent style or format; they are presented basically as the authors submitted them to HERO.

A draft of this report was circulated to all In-Process Review participants who are quoted by name in the report, and to other senior participants. Their comments and corrections have been incorporated into this final report. It is assumed that any period between draft and final reports were satisfied with the report's accuracy and completeness.

MAIN REPORT

IMPLICATIONS OF PRESENT KNOWLEDGE AND PAST EXPERIENCE FOR A POSSIBLE FUTURE CHEMICAL/CONVENTIONAL CONFLICT

GAY HAMMERMAN

Historical Evaluation and Research Organization
A Division of Data Memory Systems, Inc.
8316 Arlington Blvd, Suite 400
Fairfax, Virginia 22031

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IMPLICATIONS OF PRESENT KNOWLEDGE AND PAST EXPERIENCE FOR A POSSIBLE FUTURE CHEMICAL/CONVENTIONAL CONFLICT

Objective of the Project

This project had the stated objective of stimulating fresh thought on the subject of possible future chemical warfare, not only by those currently involved in thinking about and planning for chemical deterrence and defense but also by a much wider group throughout the defense community. HERO planned to accomplish this objective by recruiting knowledgeable people from outside the core defense community and providing a structured process that would allow them to formulate and present their own thinking on future chemical warfare; to react to each other's ideas; and to develop new insights and concepts. The presence at the In-Process Review for the project both of representatives of the Study Advisory Group for the overall project of which this is a part and also of persons from a number of defense agencies and scientists from academic institutions made possible a wide exchange of views. This report is intended to continue the purpose of disseminating and stimulating thought about possible future chemical warfare in order to build a rational and broadly supported program of chemical deterrence and defense.

Classification

All papers prepared for this project, all presentations and discussions of the In-Process Review, and this report are Unclassified.

Methodology

Since the objective of the project was to stimulate new thought on chemical conflict, it was decided to seek a way of looking at possible future conflict without any current assumptions. Three areas were seen as providing possible clues to what future chemical conflict would be like: the historical experience of past chemical combat; the nature of contemporary and anticipated chemical agents; and the weapons, equipment, doctrine, and training which Soviet forces would bring to such future warfare. US and NATO capabilities were deliberately not examined, because this material was believed to be more familiar.

It was decided to ask two historians, two scientists, and two Soviet specialists, all of whom had some knowledge of chemical warfare as it related to their fields, to write papers describing what they thought a chemical/conventional conflict in the late 1980s would be like if they knew nothing about such a conflict except the special knowledge of their own disciplines -- what the past chemical conflict had been like, or what the nature of the agents themselves dictated, or what Soviet capabilities and doctrine dictated. These papers were then to be circulated among the participants, and each was to modify his/her own picture of a future chemical conflict as he/she saw fit, in the light of the other papers. Then all participants were to meet for the In-Process Review, present their papers to each other and the other knowledgeable persons attending, and develop, through discussion of the papers, an integrated picture of future chemical conflict, with points of remaining disagreement identified. A final report summarizing the papers and discussions would then be prepared.

This methodology was followed fairly closely. Only one historical paper was prepared for the project and circulated, but two other scholars who are currently engaged in research on the history of chemical warfare were able to present papers at the In-Process Review. None of the papers presented a detailed description of a future chemical conflict. Since another part of the overall project of which this effort was a part was devoted to a very extensive and detailed description of such a conflict, the future-conflict description did not seem to merit a high priority. In fact, after consultation with representatives of the principal contractor, participants were told not to deal with matters of specific military judgment, since these were already being handled by senior military specialists. Nevertheless, participants were constantly urged to focus on <u>a future conflict</u>, and this focus meant that -- whether discussing World War I history, Soviet chemical tactics, or military applications of toxins -- the participants did devote their attention almost entirely to what was relevant to future conflict, rather than just giving background summaries of their subjects.

Definitions and Assumptions

<u>Chemical warfare</u> as used in this report and in connection with this project is understood to mean chemical/conventional warfare.

<u>Future chemical war</u> or <u>conflict</u> is understood to mean a hypothetical chemical/conventional, nonnuclear war in about 1990.

It is an assumption of this project that there will be no change in current US policy, and thus the United States would not initiate any future chemical conflict.

Because of the necessity to limit the kinds of possible future conflict being considered, in order to say something meaningful within the time and effort constraints of the project, it was decided to limit the conflict under consideration to one in Europe between the Warsaw Pact and NATO.

Organization of This Report

The organization of this report will follow that of the In-Process Review meetings. A summary of the introductory statements made at the Review will be followed by analytic summaries of the papers and discussion on chemical warfare history, Soviet capabilities and doctrine, and the scientific/technological nature of future agents. The Review's concluding discussion will then be summarized, and the report will close with a brief essay on constant motifs that emerged from the meetings. Papers presented at the meetings are appended to the report.

Introduction to the In-Process Review Meetings

Dr. Ted Gold, Deputy Assistant to the Secretary of Defense for Chemical Matters, noted that thinking about possible future chemical warfare is now in a transition phase. After years of believing and hoping that there was no problem, and then being forced to recognize that there is a threat, the country now has to form a rational consensus on what should be done about it. Dr. Gold asked the participants to join in raising the level of debate by increasing their own knowledge, increasing the knowledge of other people involved with chemical warfare matters, and increasing the number of people who are concerned and knowledgeable.

In previewing the topics to be focussed on at the meetings -- historical experience, Soviet capabilities and doctrine, and scientific nature of the agents -- Dr. Gold asked that special attention be paid to Soviet <u>intentions</u> (in contrast to capabilities, about which he felt there was general agreement) and, with regard to the nature of the agents, to radically new and different agents that may appear in the near future.

The Historical Experience

Col. Trevor Dupuy of HERO introduced the presentations on historical experience by drawing a distinction between revolutionary and evolutionary change in military technology, giving some historical examples, and suggesting how historical analysis can distinguish quantitatively between the two.

Colonel Dupuy classified changes in military technology as revolutionary or evolutionary on the basis of their effects on battle casualties. As an example of a technological development with evolutionary effects, he cited the VT, or proximity, fuze, introduced against ground troops in late 1944. The VT fuze, he said, increased overall artillery effectiveness by a factor of only about 1.1 -- a change, but not a revolutionary one.

On the other hand, two technological developments that <u>did</u> have revolutionary effects were the high-explosive shell and the field telephone. From 1861 through 1871, in four major wars, artillery fire accounted for slightly less than 10 percent of total casualties, and small arms fire -- its lethality greatly augmented by the introduction of the conoidal bullet -- accounted for almost 90 percent. But after the introduction of the high-explosive shell and the field telephone, artillery caused more than 50 percent of non-gas casualties in World War I, while small arms -- even though these now included machine guns -- caused only about 40 percent. Artillery effectiveness was increased by a factor of about 5.0. This was a revolutionary change. Colonel Dupuy pointed out that of the two technological innovations, the field telephone, by permitting indirect fire, had the stronger effect by far, thus demonstrating that nonlethal technological innovation can have revolutionary military effects.

Applying this analysis to chemical warfare of the future, Colonel Dupuy asked what kind of future developments might have revolutionary effects on chemical conflict. He suggested that any technological developments that completely negated the value of protective clothing and breathing apparatus would be revolutionary in their effects; so also would be any new technology that enabled troops to carry out military duties in a contaminated environment unencumbered by protective clothing and masks. Such developments would drastically change the nature of the battlefield. Any other changes would probably be only evolutionary.

Historical papers were presented by Mrs. Gay Hammerman of HERO, Maj. Charles Heller of the Combat Studies Institute at Fort Leavenworth, and Dr. Victor Utgoff of the Institute for Defense Analyses. Mrs. Hammerman's paper focused on World War I experience and its implications for possible future war, with special focus on the psychological reactions of troops to the initial use of lethal chemicals. Major Heller's paper summarized the experience of the American Expeditionary Force with gas in World War I.* Dr. Utgoff focussed his presentation on uses of lethal gas between the world wars and on nonuse during World War II.

Mrs. Hammerman suggested that the constant tension between surprise and protection was the most significant feature of World War I chemical warfare. It was this feature, she believed, that would be most important in any future war, if historical experience was a useful guide.

Defense was possible in chemical warfare to an extent that set this kind of weaponry apart from -- for example -- high-explosive shell and machine guns. Even very simple protective devices -- small rectangles of flannel originally intended as rifle cleaners that were soaked in photographic "hypo" solution or urine and tied across the nose and mouth -- made a great difference in casualties and military performance during early gas attacks.

Because defense was possible, surprise was all-important in this kind of warfare. A long procession of new agents (between 38 and 50 for the war as a whole) appeared in an effort to achieve surprise and overcome protective devices. Delivery means and tactical innovations were also geared to this end: to overwhelm or circumvent the protective device or catch the enemy without protection.

* Major Heller's paper was based on a book-length study prepared for the Combat Studies Institute, which is still in draft form and has not been cleared for publication. It was therefore not possible to obtain permission to include it in this report.

Because defense was difficult -- cumbersome, uncomfortable, and degrading of military performance -- surprise was possible. For example, sometimes reserve troops well to the rear were caught without their respirators by a very heavy concentration of gas which front-line troops, warned and protected, had come through unscathed. Gas played a significant role in several near-breakthroughs, including the Italian rout at Caporetto, where the Italian troops had inadequate gas masks and poor gas discipline.

In any future chemical war, Mrs. Hammerman believed that an attacker would seek surprise above all. In a period like the present, when both sides possess and are protected against a variety of agents, the chief means of surprise sought would logically be an agent different enough to break through or around existing defenses. This was also the situation during much of World War I, and the search for a new agent was won by the Germans with the introduction of mustard. Those planning to deal with a future chemical conflict have to be alert for a mustard of the future.

Uses of chemicals in a future war, based on World War I experience, would be

- nonpersistent agents used in mass against the first echelons of defending troops as the first strike of a massive combined offensive

- attacks on artillery and missile positions

- persistent agents used to isolate segments of the battlefield, keeping the defender from bringing up reserves

- use against reserve troop concentrations and supply lines

- harassing bombardments against holdout positions, for attrition and to keep defenders in protective gear.

As for the psychological reactions of troops, Mrs. Hammerman stated that protection and training were the keys to unit cohesion and effective performance in the face of gas attacks in World War I, and presumably would be in the future. The chief threat of chemicals to positive troop behavior in that conflict, she said, was not so much the mysteriousness or insidiousness of the weapon but rather the fact that because it was new, unexpected, and had not been trained for or protected against, men initially panicked through not having any well-inculcated procedure to follow.

Following Mrs. Hammerman's presentation, there was discussion of the slide she showed, which presented graphically the relation between gas casualties, nongas casualties, and hospital admissions for nervous disorders. The discussion concluded in agreement that the slide simply showed that intensity of combat was reflected in nervous (or psychiatric) disorders. The number of gas casualties was too small in relation to the number of nongas casualties to have any significant measurable impact on hospitalizations for psychiatric reasons.

A question was raised as to the applicability of experience in World War I -- a static war -- to a possible future war, which will presumably be highly mobile. A participant pointed out that in the last year of the war, when use of gas was greatest, the war was not, in fact, static. This was the year of the great German offensives, in which gas was intensively employed, with carefully planned tactics, and of the final Allied offensive, which also employed much gas.

Mr. Bodansky also pointed out the widespread use of gas in the mobile warfare on the Eastern Front in World War I. Casualties were reportedly much higher there.

Thus considerable historical evidence was cited to show that chemical weapons can be effectively used in mobile warfare. Analysis of the Eastern Front experience is made difficult by the destruction or disappearance of virtually all Soviet military literature produced during the 1920s and 1930s (Mr. Bodansky), but further study of the use of gas in the Western Front 1918 offensives should be possible and useful. Major Heller's forthcoming book on the AEF experience with gas is expected to include analysis of 1918 mobile gas tactics.

There was considerable discussion of the Germans' failure to exploit fully their initial breakthrough with the first use of gas in 1915. Colonel Dupuy confirmed Dr. Utgoff's suggestion that there has generally been inadequate exploitation of the first use of new weapons. A question was also asked as to the Germans' perceived failure to exploit their one-year monopoly on mustard. Here the answer was that they made good use of mustard, but that it was primarily a defensive weapon; its persistence and delayed effects made it useless as preparation for a combined arms attack. It is not likely that it could have been exploited in any way that would have led directly to a decisive breakthrough.

In his presentation, Dr. Utgoff summarized the history of use and nonuse of chemical weapons since World War I, focussing on a group of situations in World War II in which chemical weapons might reasonably have been used and were not:

- by France against the Germans in the campaign of 1940;
- by the British against a German invasion of Britain in 1940 (he concluded that chemical weapons would have been used in this case if needed);
- by the Soviet Union against the German invasion of 1941;
- by Japan in the Marianas campaign;
- by Germany against the Normandy landings;

- by Germany at the end, as a last resort;

- by the United States in support of an invasion of Japan.

Utgoff concluded that, while deterrence -- that is, fear of retaliation as a factor mitigating against use of chemical weapons -- was always operating in the minds of decision makers, it did not always determine the decision that was made. There were situations in World War II, he believed, in which chemicals would have been used if they were needed, despite the possibility of retaliation.

Some participants took issue with Dr. Utgoff. Dr. Brooks Kleber stated that he believed the same cases that Utgoff cited could be used to demonstrate the effectiveness of deterrence. Utgoff then made it clear that he was not saying that deterrence didn't work but rather that it was not a neat mechanism that could always be counted on to work.

Soviet Capabilities and Doctrine

Soviet capabilities and doctrine were presented by two specialists with contrasting points of view. They agreed that the Soviets have a massive chemical capability, a capability far exceeding the NATO/US capability, as to weapons quantities, group protection (including protection of vehicles), and thoroughness and realism of training. The Soviets, it was agreed, are well prepared to fight in a contaminated environment. There was also agreement that if the Soviets did use chemical weapons, they would fully exploit the advantages of surprise, using the weapons without warning to achieve a strategic objective. There was agreement that the Soviet Union would not be deterred from using chemicals by any current US/NATO capability to retaliate with chemicals, but there was also agreement that the Soviets would prefer to win a conventional war in Europe without recourse to chemicals and that they believe that they could in fact win such a war with conventional weapons alone. There was agreement that if the Soviets felt it was to their advantage to use their chemicals, they would not hesitate to do so.

Dr. Allan Rehm, of Science Applications, Inc., and formerly of the US Central Intelligence Agency, stressed the speculative nature of any judgments about future Soviet use of chemicals. He thought that Soviet leaders probably believe they can win a conventional war in Europe and will not need chemical weapons. At the same time, if they should wish for any reason to escalate to weapons of mass destruction (this Soviet term includes nuclear, chemical, and biological weapons), they might well move directly to nuclear weapons to preempt such a move by the United States/NATO. The logic here is that, since the West has a negligible chemical retaliatory capability, Soviet use of chemicals would seem, to the Soviets, likely to bring a NATO nuclear response. Therefore, it would make sense for the Soviets to use nuclear -- possibly along with chemical -- weapons first.

In any case, Soviet use of chemicals in an otherwise conventional conflict seemed doubtful to Dr. Rehm. He saw no evidence that use of chemicals was an integral part of Soviet contingency planning for a future war.

Mr. Yossef Bodansky, an Israeli citizen and independent consultant who was recently Visiting Scholar at the Johns Hopkins School of Advanced International Studies, presented a contrasting view. Mr. Bodansky saw the Soviet Union as intending to win any possible future conflict in Europe without nuclear weapons and within 10 to 15 days, with the option to use chemical weapons an integrated part of the plan. He pointed out two "choke stages" in the tight Soviet timetable for such a war: the completion of the breakthrough of the NATO first line of defense and the conduct of offensive military operations in NATO's deep rear. He said that if delays appeared imminent at these stages, the Soviets would not hesitate, and were fully prepared, to use chemicals to keep to their schedule. Bodansky stressed that local commanders, down to the regimental level, would have the authority to initiate use of chemicals at their own discretion to solve local crises that threatened the timetable -- always assuming that the decision had been made at the highest political level to use chemicals if necessary. He acknowledged that there is no explicit evidence of these Soviet intentions, but believed that they can be inferred by carefully probing Soviet capabilities as to training, weapons, equipment, and doctrine, as revealed in the open literature.

Dr. Rehm stated that although Soviet training is very thorough, making use, for example, of diluted lethal agents, it seems to be training for defensive operations only. In some older field exercises there was offensive use of chemicals, but this was always either concurrent with or following use of nuclear weapons. There may be offensive training now, but if it were given to all troops, we would probably have evidence of it. It is possible that it is being given only to selected troops, in which case it could escape detection, so the existence of <u>some</u> training for offensive use cannot be ruled out, but no evidence of it is available.

Dr. Rehm stressed the connection in Soviet minds between nuclear weapons and chemical weapons; they are grouped together as "weapons of mass destruction." If the Soviets considered using chemical weapons in a given situation, they would probably also be considering using nuclear weapons. It should be noted that Dr. Rehm's emphasis on the "weapons of mass destruction" concept -- the grouping of nuclear and chemical weapons together in Soviet minds -- was in contrast to Mr. Bodansky's stress on the Soviet concept of "nonnuclear war" -- the grouping of conventional and chemical weapons together in Soviet minds.

Dr. Rehm did find one strong, frequently repeated theme in Soviet writing that suggested a significant motivation for Soviet use of chemicals: the importance of recovery and reconstruction after any war, and the consequent need to preserve the enemy's material infrastructure. Chemical weapons could make it possible to overcome the enemy while at the same time avoiding physical damage.

Dr. Rehm said he thought the Soviet General Staff would consider our present defensive capability inadequate for effective operation in an intense chemical environment, despite discussions implying the contrary that have appeared in the Soviet press. He was also concerned about a dilemma he saw the United States facing with regard to chemical deterrence: Improved US capabilities in chemical warfare would help deter war, but if war should nevertheless occur, a stronger US chemical capability would increase the incentive for the Soviet Union to escalate to nuclear weapons. Recognizing this risk, he nevertheless believed that the war-deterrent effect of increased US chemical capability should be acquired, and he stressed that it must be a significant capability, and not just a token one, if it was to work as a deterrent.

So far as Soviet chemical weapons are concerned, Dr. Rehm did not judge them to be a central factor in Soviet plans for a European conflict.

Mr. Bodansky, as already indicated, did think that chemical weapons are a central, integrated part of Soviet contingency plans for a war in Europe. He came to this conclusion by drawing inferences from Soviet statements of doctrine, training practices, organization, troop numbers, size and location of weapons stores, training exercises, and policy and procedures in the civilian society.

Mr. Bodansky thought that Soviet use of the term nonnuclear, rather than conventional, in describing the initial phase of a possible future war, was significant and should not be ignored. As evidence of the weight given to chemical matters, he pointed out that the chemical training academy is the Timoshenko Academy, and that naming a training academy for a specific historical figure, and especially for such an important historical figure, indicates that the academy and the branch of service are considered very important. The school has an impressive list of scientists on its faculty, and it stresses that their work is largely research. Since their research specialties are in chemical agents rather than in such defensive matters as impermeable fabrics and shelter materials, Mr. Bodansky inferred that they are doing research in new agents for offensive use.

There are almost 1,000 chemical training ranges, Bodansky noted, and over 90 percent of them are dedicated to training troops throughout the armed forces, with only the small remaining minority devoted to chemical troops. He stressed the constant drill in donning protective gear, not only in the armed forces but throughout the civilian population, from early childhood on. Logically, all this training and drill could be defensive, and in the case of the civilians, simply a part of the Soviet civil defense system, but Bodansky felt that the extent of preparation for operating in a contaminated environment, considering the low level of any realistic US/NATO threat, implied preparations for using chemicals in case of war. (Rehm, on the other hand, said that Soviet leaders really seem to believe that there is some possibility that NATO will make a first-use attack with chemicals.)

All Soviet weapons have the capability to fire chemical shells, Bodansky noted. According to British estimates, there are now about 40 depots in Eastern Europe that we know are devoted to chemical munitions. Estimates going back to the 1950s suggest that 30 percent of munitions were chemical then; recent British reports are that 50 percent now are chemical. These figures, Bodansky suggested, show clearly that the Soviets are prepared to use chemicals in any European war, should the need arise.

As for the question of offensive use of equipment, Bodansky stated that Soviet civil defense plans do not allow for ordinary urban streetcleaning equipment to be used to decontaminate city streets. This is because it will be with the troops in case of war. What, then, are the Soviet spray tanks, supposedly designed for decontamination, to be used for? The inference drawn is that they are actually intended for dispersal of chemical agents.

As further evidence that the Soviets are training and preparing for offensive use of chemicals, rather than for defense only, Bodansky cited the fact that the senior chemical troops officer of each regiment is on the regimental staff, and that he serves under the fire officer, along with the regimental artillery commander. Furthermore, graduates of two of the three chemical officer schools are combat officers, authorized to command combined arms teams, employing artillery and tanks. They are not involved simply with decontamination and protection.

Two other items of evidence had to do with tactical matters. In 1976, following what is known as the BMP debate, it was decided by the Soviet military leadership that the motorized rifle subunit, when attacking with use of conventional weapons, should normally attack on foot. However, in a major exercise conducted in 1981 -- an exercise whose results are compared in significance by the Soviets with those of the Great Patriotic War -- there was one example of a breakthrough which the Soviets dealt with in unprecedented detail as to timing, depth of advance, number of weapons systems involved, and other factors. This was the breakthrough of a leading battalion of one of the motorized rifle divisions. The Soviet analysis emphasizes that all troops advanced inside the vehicles with hatches closed, troops shooting through rifle ports and driving straight through, with much smoke used. As this exercise demonstrates, Bodansky said, Soviet tactics have been changed from the earlier practice of infantry attack on foot, so that it is now possible for chemicals to be used offensively on last-minute notice at the discretion of local commanders, without any necessity for change in the operational posture of the troops.

The second of these tactical evidence items had to do with what the Soviets call "dazzling smoke." Again, Bodansky clearly believed that dazzling smoke is a code term for chemical warfare agents. The Soviets describe a dazzling smoke screen as smoke that is disseminated directly into enemy dispositions, covering ground observation points and fire positions and making it impossible for the enemy to conduct observation of the battlefield and aim his fire. Bodansky cited literature on tank operations stating that an ordinary smoke screen, placed between friendly troops and enemy positions, is sufficient to protect advancing tanks, and asked why the doctrine that both a camouflage smoke screen and dazzling smoke were necessary to protect one's troops was set forth in 1978.

In summary, Mr. Bodansky saw a strong Soviet emphasis on -- in Soviet terms -- winning a strategic victory in the initial, nonnuclear period of any future war, and saw evidence that was ample, even though it had to be carefully analyzed and interpreted, that use of chemical munitions was an integral and important part of the way this goal would be achieved.

The group discussions following these two presentations carried on the implied debate between these contrasting points of view. A member of the defense intelligence community expressed considerable skepticism about a number of Mr. Bodansky's conclusions. For example, Bodansky had cited the rapid promotion of Gen. Col. V.K. Pikalov, head of Soviet chemical forces, as evidence of the importance given to Soviet chemical warfare, but the discussant said that there were a number of other very clear reasons for Pikalov's rise. Further, in noting the huge number of Soviet chemical troops (80,000-100,000 in peacetime), it had to be remembered, this discussant felt, that these troops have duties other than chemical combat, including nuclear, biological, and chemical decontamination. Dr. Rehm was asked how the Soviets could really believe that the United States/NATO would use chemical weapons first, given the great inferiority of Western chemical capability. He responded that the Soviets see the United States as unpredictable. Dr. Rehm also believed that the Soviets are influenced by the propaganda they disseminate to their own troops; it is important to the Soviets that their troops believe in the rightness of what they are doing, if military operations are to run smoothly. Mr. Bodansky did not believe that Soviet leaders were influenced significantly by Soviet propaganda, and did not think they were concerned about a possible US/NATO attack.

Mr. Bodansky had brought to the meetings a complete set of Soviet protective clothing, captured in Afghanistan. In his presentation, he stated that Soviet regulations provide for a military unit to receive chemical gear only when it is going to be exposed to chemical weapons, citing the presence of the suit in Afghanistan as one item of evidence that chemicals are being used there. Lt. Col. Kenneth Neher of OSD described the outfit in detail, explaining how it is worn. There was discussion of its advantages and disadvantages in relation to US gear. Basically, it is an impermeable garment, even more uncomfortable than the US counterpart, but providing very effective protection for the short periods it can be endured and easy to decontaminate by hosing down. In discussing the Soviet suit, Mr. Bodansky stated that there are two ways in which the suit may be donned: the first, with mask put on first, is for fastest emergency use; the second, in which boots, overcoat, and gloves are donned before the mask, is for cases when there is ample warning. Bodansky stated that the rules for donning have now been changed, and the second method is the standard one. This has been possible, he said, because the Soviets know they will have ample warning; they know that the Western powers will not attack with chemicals.

In a later discussion, Dr. Elizabeth Rock, of Wellesley College, a chemist with a background in chemical defense, asked why, if the Soviets plan offensive use of chemicals, they don't have a mask that provides better vision and communication. Bodansky answered that there is a new Czech mask that is better, but that in any case the Soviets were not planning to fight in the protective suit and mask, but only to move from one protected vehicle to another. (The second vehicle would be an evacuation vehicle, Bodansky explained, so that its contamination would not matter; it could be decontaminated when it completed its mission.)

A question was raised about use of chemicals against naval forces, and Dr. Rehm answered that we were not prepared. Ms. Amoretta Hoeber, Principal Deputy Assistant Secretary of the Army (Research, Development and Acquisition), commented that some new US vessels have ventilation systems that would make a chemical attack worse by sucking chemical agents into the interior of the ship. In another discussion, the following day, Dr. Joshua Lederberg made the same comment about a number of our land vehicles, and noted that the Soviets have so designed their vehicles that they avoid this problem.

There was discussion of the possibility of accidental chemical war, given the large amount of Soviet chemical munitions in Europe. There was mention of the possibility of a less-than-massive use of chemicals by the Soviets, if the Soviets feared a massive use would bring nuclear retaliation. This is something that apparently concerns some of our European allies, and it would be confusing and difficult to respond to. There were questions and disagreements about the level at which Soviet authority to use chemical weapons would be given. The discussion ended with complete agreement on the massiveness of the Soviet capability, and the disparity between it and the US/NATO capability, but with two clearly delineated points of view as to whether the Soviets intended to use that capability in the initial phase of a future war in Europe.

The Scientific Nature of Future Chemical Agents

Although neither of the two scientists who spoke on future chemical warfare -- Dr. Michael Wartell and Dr. Calvin McLaughlin -- gave a detailed description of a hypothetical chemical battlefield, both offered a large number of clues as to what might be expected, based on the nature of agents, detection techniques, and other scientific/technical elements of chemical warfare.

Dr. Wartell, Dean of Letters and Sciences at James Madison University and a chemist with considerable background in chemical warfare matters, presented data and analysis supporting a point of view on technical matters that had some points of similarity with Mr. Bodansky's point of view on Soviet capabilities and doctrine. Dr. Wartell stressed the disparity between a US chemical effort that has been static for 15 years and a vigorous Soviet effort with a corresponding 15-year lead. He saw the future US soldier attempting to fight on an extremely hostile chemical/biological battlefield, protected only by an uncomfortable, cumbersome mask and clothing, unable to detect the presence of many chemical or biological agents that could be used against him, and unable to force his enemy into similarly handicapping protective gear.

Basically, this situation could come about because the Soviets have a bounded problem, while the United States has an unbounded one. The Soviets know what agents we have in our stockpile. We have not developed or produced any new ones for 15 years. It is likely that the Soviets have been pursuing research and development, and that they have offensive capabilities of which we are not aware. Thus, the United States has a static and possibly deteriorating stockpile of chemical warfare agents and no biological warfare agents. The Sovet Union has a stockpile of agents similar to that of the US, but much larger and packaged in munitions for a much larger variety of weapons, plus, probably, a number of newer chemical agents and a stockpile of biological weapons of unknown size.

Defense against chemical and biological agents is carried out on both sides by the triumvirate of detection, protection, and decontamination. For detection, the United States will have in the field by 1988 an automatic chemical agent detection and alarm system, based on the principle of ion mobility spectrometry (as is the so-called CAM system which is now in production). It will identify known persistent agents, principally mustard and nerve gas. Although little is known about Soviet detection capabilities, the static nature of US offensive capability should make the Soviet detection problem a limited one. The Soviets have no need for detection of biological agents, except in cases where they are using them themselves; the United States is in the earliest states of developing detection methods for biological agents, including protein toxins.

Protection for the individual is similar for both sides. Differences in the protective gear have been discussed above. Dr. Wartell did not discuss differences in vehicle and shelter protection, but it was clear from earlier presentations and discussions that the Soviet Union has a marked advantage in this area. [In the discussion following Wartell's talk, the comment was made by a participant that US failure to protect the M-1 tank was not a decision based on a reasoned weighing of tradeoffs, but was rather simply an error of judgment. It was also noted that our allies are doing better than we on vehicle protection, and that we can be expected to do better in the future.]

In brief, Dr. Wartell's statement about detection, protection, and decontamination was that the US was reasonably well prepared against known Soviet agents, although inevitably encumbered in battle by protective measures, while the Soviet Union could be assumed to be well protected against any US threat, since that threat is limited and well known.

In visualizing a future chemical/biological war, Dr. Wartell explored what the results of this bounded Soviet problem and unbounded US problem would be. With regard to detection, he saw the possibility of Soviet use of chemical agents that would not trigger US detection alarms, such as non-phosphorus-based nerve agents or quick-acting toxins. Alternatively, harmless chemical agents that did trigger the alarms could enable Soviet troops to fight unencumbered while US troops were hampered by protective gear. When the alarm was determined to be false and gear removed, real lethal agents might be released.

Protection could be overcome by overwhelming the charcoal filter with so much agent that all charcoal was inactivated. Another means would be to develop an irritating agent, which might be nonlethal, that passed through the filter, forcing the soldier to remove his mask and fall victim to the lethal agent that was also present. (It was pointed out during the discussion that this technique had been widely used in World War I.) Protein toxins, which are not now readily detected, could be used.

Wartell also suggested a number of possible technological developments that might be used in such a future war. These included antimateriel chemical agents that would attack electrical insulation, lubricants, or other essential components of war equipment, and genetically engineered disease organisms against which one's own troops would be immunized and which would not be responsive to treatment.

In summary, Dr. Wartell's picture of a hypothetical future war was one in which the US soldier would possess an ineffective mask and clothing, would be unable to detect chemical/biological attacks, and would be unable to decontaminate materiel and personnel. He also visualized Soviet tactics that would use both new and old chemical/biological weaponry in ways that caught US troops by surprise and unprotected. To prevent such a conflict, he favored a more credible deterrence based on continued and intensified defense efforts and an effective chemical/biological arsenal.

During the discussion following Dr. Wartell's presentation, Dr. Joshua Lederberg, President of Rockefeller University, made a number of contributions. Noting Dr. Wartell's point that the Soviets' defensive problem was bounded, while ours was unbounded, he expressed doubt that this was really so, since, knowing what the fundamental US capacity was, the Soviets could hardly believe that their problem was bounded. Wartell acknowledged that that was one possible perception of the situation.

Dr. Lederberg discussed the problem of decontamination, one area in which he said the Soviets clearly do have an advantage. He expressed special concern about contamination of aircraft cockpit and gear. We have no way to decontaminate our aircraft now or in the foreseeable future. All we can do is redesign the equipment. Meanwhile our ventilation systems suck up contamination from outside. (Col. Felix Kozaczka of the Rand Corporation felt there was great danger to electronic equipment, especially from persistent chemical agents that would be sucked into vehicles.)

Lederberg added another concern about air vulnerability: the level of toxic agent that incapacitates a pilot is 1/100th or 1/1,000th of that required to incapacitate an infantryman.

A significant question asked during this discussion was whether there were prospects of new chemical weapons that were so different from earlier ones that the defenses against older weapons would be useless, and the possibility of defense would no longer be a key characteristic of chemical warfare. Was there a time in the foreseeable future when there would be no greater protection against a chemical weapon than there is against a 155mm high-explosive shell? The question was not answered explicitly during this discussion, but it seems accurate to say that the answer that emerged from the conference as a whole was "no."

There was considerable discussion on the capabilities and value of persistent weapons. The question was, can a persistent agent really deny terrain to an enemy? The answer given by military people present was that if a commander is willing to pay the price, terrain saturated with persistent agents can be traversed or even occupied. Dr. Wartell suggested that, assuming new agents and special efforts to overcome protection, terrain could be denied in the future. Dr. Utgoff gave statistics showing how expensive terrain denial was in World War I, because of the huge quantities of agent that had to be used. Maj. Robert Pryor of the US Marine Corps said that the term terrain denial is not much used now, because it is not accurate. Use of a persistent agent to delay enemy troops would be subsumed, in operations orders, under the heading barrier plan or obstacles. The concept is to delay, not to deny. Dr. Lederberg stressed that it was not a question of using persistent agents for absolute denial, but rather of some optimal mix of chemical and conventional weapons. In runway busting, for example, a small amount of persistent chemical would certainly delay repair.

Mr. Bodansky mentioned a new nerve gas, reportedly used in Afghanistan, that is much more lethal than ordinary nerve gas. According to reports he has received, personnel delivering this agent by helicopter are now wearing full protective gear, whereas with ordinary nerve gas this has not been necessary. This agent reportedly causes instantaneous death, freezing those attacked in place. In answer to a question Bodansky said that Smirch is one of the names given to this agent.

The discussion closed with an exchange on the relative importance and contributions of intelligence vis-a-vis research and development in improving the US chemical deterrence posture. Asked whether he thought better intelligence on Soviet capabilities would help bound the US defensive problem, Dr. Wartell agreed that it would, but felt that intelligence success could not be guaranteed, and that more R&D on detection and protection would be a more fruitful path to follow. Dr. Gold said that it was not sensible to pour large resources into R&D without a firmer intelligence base, but Dr. Wartell maintained that more R&D on general defensive measures, among which he mentioned physiologically based detection systems, was the most fruitful approach. (Dr. Calvin McLaughlin discussed this detection approach quite fully in his presentation; see below.) There was, of course, general agreement that both intelligence and R&D were essential, plus a recognition of the point made by Lt. Col. Kenneth Neher of OSD: we can never be even with the Soviet Union in intelligence. It's a price we pay for living in an open society.

The special contribution of Dr. Calvin McLaughlin, the other scientist who spoke, was the clear explication of the ways in which much more lethal toxins might be developed for battlefield use in the next few years, and of how they might be protected against. Dr. McLaughlin, a Professor of Biological Chemistry at the University of California, Irvine, confirmed what most military and lay people who are concerned about chemical warfare have suspected -- that a scientific/technological revolution with a strong impact on chemical warfare is now in progress.

All existing chemical warfare agents -- and agents that could potentially be used in chemical warfare -- can be made much more toxic, perhaps 1,000 times more toxic, by a combination of (1) genetic engineering that enhances the toxicity of the agent involved and (2) the development of new agents that greatly enhance the penetration of the agent through the skin. At the same time, recently acquired understanding of how toxic agents react biochemically with cell components of the human body to injure and kill shows that the problem of defense is a bounded one. Quick, automatic, agent-specific methods of detection are the key to defense, and are achievable.

The facts of toxic agent behavior are these, to quote from Dr. McLaughlin's paper: "The toxic compound . . . binds to and inactivates one or at most a few of the cellular components that are essential for life. There is a highly specific interaction between the toxin and an essential protein receptor molecule in the cell." For example, hydrogen cyanide binds to hemoglobin and prevents its use as an oxygen carrier. Nerve gases bind to the acetylcholine esterase protein and keep it from carrying out its key role in neural transmission. This is the consistent pattern for all toxic agents that have been studied: the toxin binds to a specific cellular receptor. It is important to understand that the number of cellular receptors is limited; this limits the problem of defense. There are 100 nerve gases, but all of them bind to the same cellular receptor. If this binding can be prevented, the human body is protected against nerve gas.

New developments aiding chemical offense will come in several ways. Completely new toxic agents, in contrast to known agents that are made more toxic, will probably be discovered by accident, as dioxin was. These agents and their nature will be discussed in open literature. (This assumes that such discoveries will be made in the West, but Dr. McLaughlin seemed to believe that they would be; almost all the basic scientific work in these fields is being done in the United States and Western Europe, he indicated.) Methods of detecting and protecting against them can thus be devised.

More increases in lethality will come from enhancement of existing highly toxic agents, most of which are proteins. Once a scientist has the DNA gene for Indian cobra venom in hand, for example, he or she can rearrange and splice its components to create a more lethal agent. A large protein molecule can be pared down to a smaller one that contains all the toxic characteristics of the larger one in more concentrated form, and, being smaller, is also likely to be more stable.

Also greatly strengthening chemical offense is the current development of agents that enhance the penetration of drugs -- and thus toxins -- through the outer layers of the skin. These are being used, for example, to administer anti-motion-sickness medications by a "Band-Aid" applied to the skin. If the penetration properties of these agents can be built directly into the toxin molecule, which McLaughlin implied may be possible, the toxin's lethality would be still further enhanced. Increased or decreased persistence, as desired, could also be built into the toxin molecule.

Dr. McLaughlin did not favor US research on the enhancement of toxins, suggesting that the danger of their being transferred to the Soviet Union by espionage was great, and that possession of enhanced toxins was not necessary in order to protect against them. However, he did indicate that a research and development effort to increase dramatically the effectiveness of chemical warfare agents over the next decade would require only a small percentage of the funds currently devoted to nuclear research and development -- by either the United States or the Soviet Union.

Knowledge of the basic mechanism of toxin behavior -- each toxin binds to one and only one cellular receptor -- also provides keys to effective defense. Discovery of completely new toxins will be extremely rare, and will be reported in the open literature. The new techniques for enhancing the lethality of existing toxins produce agents that are much more lethal but that operate in the same manner on the same cellular receptor. What protects against existing agents will protect against the enhanced agents.

The key to effective defense will be above all, detection. Of the trinity of chemical defense -- detection, protection, and decontamination -- protection will not be greatly affected. Toxins are most effectively distributed by aerosol, and a suit and mask that protect against aerosols -- admittedly not easy to achieve -- will protect against the enhanced toxins. The current protective suit will need to be improved to correct extreme discomfort and degradation of military performance, but the principles are sound. Agents that can break through the protective suit are generally relatively low in toxicity. In response to a question, Dr. Mclaughlin said that even the highly toxic enhanced agents are not as extraordinarily toxic operationally as one would expect. They have to be dispersed by aerosol, which means that they have to be diluted with dispersants, and they are also considerably diluted by the air when they are delivered.

With the enhanced toxins, however, detection becomes extraordinarily important. These can be present in lethal amounts without being detected by the human senses. Here knoweldge of the mechanism by which the toxin poisons is extremely useful. Cellular receptors for all potential warfare toxins can be isolated, not an impossible task, since the number of receptors is much smaller than the number of toxins. These can then be reproduced in quantity and used in detection devices. An especially promising possibility is the incorporation of receptor proteins directly into semiconductor devices. The presence of the toxin would be detected when it became bound to the cellular receptor and thus changed the conductivity of the device. Such a detector would have a speed, accuracy, and specificity far beyond any now available, and could be tied directly to microprocessors for computer analysis of the data.

The detector would contain a large number of different cellular receptors; there would be perhaps 30 lights on its display panel, each indicating that a different specific receptor was being attacked. There would be one light for all the nerve gases, one for the approximately 60 tricothecenes, one for each of the other receptors that is attacked by any of the known toxic agents. In answer to a question, McLaughlin said that there would be "30 lights and only one bell" -- in other words, no matter what receptor was being attacked, the protective measure would be the same -- don protective clothing. However, the identification of the specific cellular receptor that is being attacked, plus the possibility through genetic engineering and molecular biology of creating antibodies that will bind to the toxin, can make it possible to save the body's receptors and the soldier's life, even if some toxin gets through the protective gear. Thus specificity in identifying the toxin will be important for treatment of casualties. It will also make possible much more effective decontamination, geared to the specific toxin.

In brief, the bad news about the military impact of the revolution in molecular biology and genetic engineering is that toxic agents more lethal by orders of magnitude than those presently available can be created, and that they can be manufactured with relative ease in large quantities; Dr. McLaughlin indicated that the manufacturing facilities required were similar in size and complexity to those for baker's yeast.

The good news is the possibility of rapid, automatic, specific detection of toxic agents, and of more effective treatment of casualties. McLaughlin stressed his view that improved detection, plus improvements in protective gear, were far more cost effective in conserving troops than improvements in treating casualties.

Dr. Lederberg made a number of substantive contributions to the discussion following Dr. McLaughlin's presentation. He endorsed both McLaughlin's presentation of the facts and his conclusions, and emphasized the following points:

- The development of new offensive weapons is happening willy-nilly. Everything scientists in the medical research establishment do enhances our understanding of the way cells live and die, and our perceptions of the ways these natural processes can be interfered with. As far as the basic substratum of science is concerned, there is no real difference between fundamental, peaceful, humanitarian scientific research and the underlying knowledge that would be needed for further weapons development. The Soviets must recognize this, and must see our basic research as research leading to new biological weapons. Whether we like it or not, we're in a chemical/biological warfare race. It's a strange race, because we claim we're not in it, but in a sense we can't help ourselves.

- There is one specific technological threat that should be singled out and given special atttention. In principle, it should be possible to develop perfect prophylaxis against any weapon that one wished to develop and use. One's own troops could then be immunized, and could go into battle unencumbered with protective gear, while the enemy had to deal with the agent unprotected or encumbered. In such a case, when the defense is so specific, defense is an inherent part of offense, and preparations for defense are indistinguishable from preparations for offense. We have to recognize these facts.

- It's true that the number of cellular receptors in the human body is limited, and that the potential agents far outnumber the receptors. But there is little point in arguing over whether there are 1,000 or 10,000 receptors. There are a great many of them, and most of them are still undiscovered. Many of them we will discover through an analysis of the action of toxic agents. Historically, that's how we've learned about 90 percent of the ones that are in the textbooks today. It will be very difficult to anticipate all the toxicities that will be discovered. Someone will discover a new toxin in nature and not publish the finding, even though most discoveries will be published.

● It's true that the barrier defense is not likely to be breached as long as conventional methods of dissemination of toxins -- like aerosols -- are used. But for the methods of sabotage or terrorism, there are disturbing possibilities. The most dangerous engineering that could be done on the botulinal toxin would not be to make it more toxic, but rather to make it less susceptible to inactivation by chlorine. If it had that characteristic, it could be 10 or 100 times less toxic than it is, and pose a devastating civil defense threat either from the Soviet Union, acting under cover, or -- and this is more likely -- from a variety of third world actors. We have here the poor man's hydrogen bomb, available at very little cost to a very large number of people. This is one point at which the interests of the superpowers seem to converge. It's not to the advantage of the Soviet Union to have a large number of actors capable of disrupting the state. (However, Lederberg said he could see no pathway by which that overlapping of interests could have a useful product.)

● In conclusion, Dr. Lederberg said he felt that discussions of future chemical warfare tended to dwell too long on the enhancement of capabilities of two superpowers against each other, when both are already capable of totally destroying one another with existing technology, and when the real difference, the real significance in future chemical/biological weapons, is the proliferation aspect.

In answer to a question, Dr. McLaughlin said that most basic research in microbiology and related areas is done in the United States, Western Europe, and Japan, with the Soviet Union doing only about 5 percent. But the technology is so simple that it doesn't really matter who does the research. This is what makes the proliferation problem so serious.

Another participant asked a question about a Soviet chemical weapon which Richard Smith of the Dignity of Man Foundation had reported seeing in Afghanistan, and which, he had been told by doctors there, burned victims initially and then apparently killed them weeks later after the burns had healed. Dr. McLaughlin gave it as his personal judgment, based on what he has read about evidence of use of tricothecene, that the Soviet Union is probably experimenting with new agents in Afghanistan. If a war in Europe were to break out tomorrow, and chemical agents were used, they would be the familiar ones that have been in arsenals since World War II. Local wars against unprotected people provide the opportunity to test new agents, like the one Smith described, or the one mentioned by Mr. Bodansky that -- according to some reports -- kills instantly.

At this point it seems important to insert a comment received from one of the scientist participants following the close of the conference. Not only should we assume that a war in Europe tomorrow in which the Soviets used chemicals would employ the standard ones now known to be in the Soviet arsenal, but in the 1990 time frame, for a war in Europe, the same thing would be true. It is important to remember, this participant said, that greater lethality is not necessarily an advantage to the user. If he is planning, as the Soviets would on the basis of all we know, to follow a "deploy forward and move through" doctrine, it would be much more important for them to have an agent that their own protective gear can see them safely through -- that is, an agent quite similar in persistence, vapor pressure, and toxicity to those thought to be in the current Soviet arsenal. Agents genetically engineered to be far more toxic might indeed be used in lcoal wars, in situations where the Soviets do not wish to occupy the territory. However, for the 1990 time frame in Europe, this participant stated firmly that the argument against drastically increased agent toxicity holds.

Why must the most lethal toxins be disseminated by aerosols, someone asked during the discussion. The answer has to do with volatility. The gases we have now are probably the gases we will have in the future. Neither their number nor their lethality is likely to be increased -- although their lethality can be greatly increased by using them in combination. However, the protein toxins whose lethality can be so greatly enhanced by genetic engineering are not gases -- not volatile. They have to be distributed by aerosol.

Dr. Wartell pointed out that a military advantage of the protein toxins, in addition to their great lethality, is the fact that current methods of detection cannot identify them. All toxins are just clusters of amino acids to current detection systems. What would now be gained by a user of toxins in lethality is nothing as compared to what would be gained in surprise. Dr. McLaughlin added that a major reason for the difficulty in persuading all reasonable people that tricothecenes have been used in Southeast Asia is the fact that it is so difficult to detect such agents.

This emphasizes the need for the kind of rapid, automatic, specific detection system Dr. McLaughlin described. Another advantage of this detection system would be the automatic warning of troops to the rear, even if front-line troops were killed before they could don gear and relay the alarm.

There was discussion of the comparative advantages of prophylaxis -- that is, pre-treatment -- and antidotes. Dr. Lederberg said that with slow-acting toxins, one may have hours to treat casualties, and in these cases an antidote can work. It is extremely important to identify the toxic agent, because the wrong antidote, acting in the absence of the toxic agent, could itself cause serious damage. Prophylaxis is better, however, when possible, because once the antagonist-agent has bound to the cellular receptor, it's hard to dislodge it. It's much better to introduce a substance that will bind to the receptor without harming it before the antagonist-agent appears on the scene.

Following this discussion, Lt. Col. James Fargo of DARCOM made a brief presentation, illustrated with photographic slides, of a Soviet 130mm. white phosphorus round which could be used to disperse aerosols. When recovered, this shell did in fact contain white phosphorus. However, analysts were puzzled by the presence of a small plug in the base of the shell which seemed to serve no purpose. When the shell was fired with liquid fill, the burster did not explode, and the shell did not detonate, but rather went low-order. Because of the resulting pressure build-up, the plug was expelled, and the liquid fill was ejected as an aerosol, with almost 100 percent dispersal. Further examination by metallurgists and other scientists determined that the purpose of the plug was aerosol dispersal.

Concluding Session

The In-Process Review's concluding session was a general discussion led by Dr. Gold. He opened it by summarizing US policy on chemical matters and asking the participants to consider whether the papers presented indicated that the realities of likely future chemical conflict were in harmony with that policy. The policy, as Dr. Gold summarized it, is

- Try to eliminate chemical warfare by the treaty route, through

    - putting verification and compliance teeth into the biological weapons convention
    - obtaining a verifiable chemical weapons ban.

- Until a treaty is achieved, have the ability to deter use of chemical weapons against us or our allies.

- Have nothing to do with biological or toxin weapons, in accordance with the biological weapons convention and, before that, with the US unilateral decision of 1969.

- Possess chemical weapons only for the purpose of deterring the use of chemical weapons against us or our allies; consider using them only if they are used against us or our allies; and use them then only in a manner intended to discourage further use. Thus we have a clear no-first-use policy with regard to chemical weapons, and their possession is not used to deter anything except the use of chemicals. There is no "chemical umbrella." Chemical weapons are not possessed to make up for any deficiency in the rest of our force, or to redress a conventional war going badly.

This policy, Dr. Gold stressed, is not a new one, but rather is the same policy this country has followed since 1969. However, our posture has changed, as a result of well over a decade of neglect, during which the Soviet Union has strengthened its posture, and we do not now have a capability that matches our policy.

We are now making improvements in defense, but could spend 10 or 100 times as much without solving the tremendously complicated problems of operating in a contaminated environment. In contrast, we have not modernized our retaliatory capability, and Gold said that the material presented at the In-Process Review reinforced his belief that there were few areas where offensive capability bought so much deterrence in relation to defense as chemical warfare. This is Department of Defense policy and strategy: Defense is not enough; the problems of operating in a chemical environment are so severe that you give an aggressor a tremendous advantage if you allow him to fight unencumbered while you have to fight in a contaminated environment. Our policy is to have the smallest possible stockpile that is sufficient to deny a significant military advantage to the Soviet Union.

How do the papers and discussions presented at the In-Process Review fit with US policy as outlined above? Gold felt that the historical papers reinforced the rightness of US policy, as did Dr. Rehm's paper on Soviet doctrine, with its suggestions that Soviet use of chemical weapons was not very likely. He felt that Mr. Bodansky's paper suggested that the Soviets would be much less likely to be deterred by the current US program. The picture of possible new technology presented by Dr. McLaughlin was also disturbing, raising doubts as to whether our current program could successfully deter or defend against these potential agents.

Dr. Gold repeatedly stressed the need for more and better intelligence, so that we can more accurately assess the threat we face and more knowledgeably decide whether our present and planned capabilities are adequate. We need to know whether chemicals are something the Soviets have because of their World War I experience and their fear of US intentions, or are something they plan to use as an integral part of any future nonnuclear attack.

In addition to better intelligence on Soviet intentions, Dr. Gold gave the other major research need as more information about new kinds of agents --- like those discussed by Dr. McLaughlin -- that might be able to revolutionize the battlefield by circumventing US defense measures.

Dr. Gold concluded his remarks by summarizing the challenges he saw for the Department of Defense on chemical matters -- that is, what needed to be done now so that chances of deterring a future chemical conflict could be maximized.

Gold's strong emphasis was on building a strong internal base of knowledge and competence. The technology base, intelligence base, and military knowledge base -- all eroded during the period of neglect and now slowly coming back -- must be enhanced. The core of people within the government who are knowledgeable and concerned must be greatly broadened. The problem of dealing with chemical warfare is too big for one small branch within the Army. When there is, within the government, widespread, informed understanding of the threat and thorough knowledge of the burdens of operating in a contaminated environment, a sound acquisition program -- which may or may not be precisely the one we have now -- will be comfortably supported by a strong internal consensus. Then the public consensus to actualize the program will follow naturally, with little need for public relations efforts. The chief problem now is that so few people are informed -- among our allies, within this country, and even within the US Government and Department of Defense.

A wide-ranging general discussion followed the conclusion of Dr. Gold's remarks. A few especially relevant points are discussed below.

Arms control efforts were discussed at some length. The point most relevant to a future conflict in Europe was the verification problem: Was it possible for us to relinquish the small offensive capability we have in accordance with an arms control agreement with confidence that any Soviet cheating would be prevented and that we would not face Soviet chemical weapons in a future conflict? Mr. Bodansky felt verification was not possible. Anything could be hidden in the Soviet Union, he said, and anything could be going on under the closed hatches of Soviet tanks. Dr. Gold said that he was barely on the other side of the line as to the feasibility of verification, feeling that it is barely possible to have an acceptable package of prohibitions and verifications techniques. He said, in answer to a question, that defensive capabilities should not be relinquished as an arms control measure -- even though this would be a much easier renunciation to verify -- because a strong defense was one of the best protections against small-scale cheating.

There was discussion of the size of deterrent needed, and Dr. Gold stressed that what we must have is not just a token on the one hand and not an offensive force approximating the Soviets' on the other, but a force that will deny the Soviets a significant advantage. Whatever it takes to do that is what we need. The Burdeshaw study and the follow-on IDA study will, it is hoped, do much to show how much is needed to do that. In any case, whether or not -- and whenever -- we can acquire new weapons, we must learn to do more with the weapons we have. We can still improve our deterrence. If, for example, we could simply do to Soviet airfields what they can do to NATO airfields, we would achieve a much improved -- if not a wholly adequate -- measure of deterrence.

There was repeated mention of incapacitant agents, which several participants believed were not given adequate attention, either at the meetings or in chemical discussions generally. Participants saw them serving many of the functions of lethal chemicals, with lower risks. Dr. Gold saw a danger to the "seamless web of deterrence" if the Soviets possessed incapacitants, and NATO did not. NATO thus could be pushed toward escalation to lethal chemicals if the Soviets used incapacitants.

Dr. Lederberg was concerned that so little had been heard about the possible Soviet use of chemicals in a limited-objective war outside Europe, about third world countries using chemicals against each other and against us, about use of chemicals in terrorism and clandestine attacks -- which might be on a very large scale, orders of magnitude greater than we have suffered so far. He was concerned about the vulnerability of our RDF to chemical agents, citing especially the severe threat chemical defenses would pose to an amphibious landing. Dr. Gold assured him that these matters were all given attention by DoD and were omitted from the present project only because of time limitations and the consequent arbitrary decision to focus on future conflict in Europe.

Further, in answer to another question, Dr. Gold said that he is not particularly concerned about the use of chemicals after or as part of a nuclear attack in Europe, partly because his training in nuclear matters makes him believe that chemicals would not be a major concern under such circumstances. <u>What is of concern is that the current chemical imbalance gives the Soviets such a strong incentive for decisive use of chemicals below the nuclear threshold, negating hundreds of millions of dollars in US and NATO effort to improve conventional capability</u>.

There was discussion of the psychological impact of chemical weapons on troops. Mr. Edward Kerlin of IDA was concerned that, because Mrs. Hammerman had found that there was no more fear of chemical weapons than of high explosive shells in World War I, participants might leave the meetings with the feeling that there would be no more fear, and perhaps not as much fear, of chemicals as of other weapons in a future war. Recent experience shows that our soldiers going into field tests with chemicals experience very high anxiety levels, higher than with other weapons.

There was agreement among those who had studied the World War I experience that, to judge from all available evidence, there was indeed no more fear of gas attack than of high-explosive bombardment among troops in that conflict. Another participant pointed out that when chemical weapons were first introduced many troops did panic, and it was only after time, experience, and training that these weapons became assimilated psychologically. Thus, there is no contradiction in saying that in a hypothetical 1990 war, which is visualized as very short, there would probably be strong psychological reactions of panic and anxiety, while in World War I reactions to gas were not readily distinguishable from combat stress in general.

The tremendous importance of training in accustoming troops to protective gear and also in preventing panic and excessive anxiety was stressed. Mr. Bodansky felt this meant a great difference between Soviet and US reactions. Soviet soldiers have been accustomed to protective gear since earliest childhood. They find it normal, if unpleasant. To them, operating in a chemical environment is something that can happen, a normal part of military operations, while for us the chemical threshold is a major threshold and chemical agents are something repulsive which we don't even want to think about.

Dr. Gold stated the need for more realistic training with simulated agents. Feedback makes training useful, and without simulated agents -- to test, for example, whether decontamination has been successful -- there can be no feedback. Another participant urged the need for live-agent training as essential to produce troop competence and confidence in operating in a chemical environment.

The need for larger-scale exercises was also stressed. This is the only way we have to approximate the problems of operating in a chemical environment. The extensive exercises that have been done could be listed on the fingers of one hand, and without this experience we can't judge how to allocate resources, what kind of force structure we need, what kind of tactics will work best. Is the British "fight dirty" approach -- that is, not to attempt decontamination -- better? The Germans and Soviets, on the other hand, put significant resources into decontamination. Only extensive exercises can give us a rational basis for making sound judgments.

Dr. Lederberg noted another problem of operating over time in a contaminated environment. What is the cumulative effect of many individually nonlethal doses? We now have no idea. If troops had to fight for days or weeks in a contaminated environment, rather than hours, this would be significant, and we don't know how to find the answer. This, Dr. Gold suggested, is an uncertainty we may simply have to live with.

Summary

At the beginning of the In-Process Review, the question was asked, are changes in chemical warfare that are anticipated by 1990 likely to be revolutionary or only evolutionary in their effects? It was suggested that revolutionary changes would be exemplified by new agents that made protective clothing useless or, on the other hand, made protective clothing unnecessary. Any other changes, including more lethal agents and better protection, would be evolutionary in effect. By that standard, the changes that are expected by 1990 are almost certainly evolutionary, at least so far as a possible war in Europe is concerned.

Although genetic engineering can produce toxins of greatly enhanced lethality, and although these may be a serious danger in third world conflicts and in the hands of terrorists, any chemicals used in a European war about 1990 would probably be the chemicals now in arsenals: nerve gases and mustard-type persistent agents. The possibility of barrier-type defenses that can keep chemicals from attacking their target -- the physiology of the human body -- will still be a central fact of chemical warfare. The burden of those defenses -- their discomfort, cumbersomeness, and the degradation they cause in military performance -- will still be a central difficulty.

The chief problem specifically related to a chemical conflict in 1990 will be the asymmetry between Soviet and US/NATO offensive chemical capabilities. The chief dilemma facing the United States in the period between now and 1990 will be determining how much and what kind of offensive capability will be sufficient to deter Soviet use of chemicals, given this asymmetry. A major task will then be the acquiring of this capability, something which cannot be done without a national consensus acknowledging the need for a deterrent and the validity of the decisions reached by the defense community on what is needed. Since all this cannot be achieved by 1990, more effective ways of using the weapons we now possess must be found.

The chief information gaps that must be filled in order to determine how much and what kind of deterrent is needed are

- more intelligence on Soviet intentions for use of chemicals in a possible European war in about 1990;

- more data on possible breakthroughs in future agents whose lethality, stability, persistence, penetration, or other characteristics have been enhanced by new microbiology and genetics technology

- more simulated large-scale, extended combat experience in a chemical environment, gained through large-scale field exercises.

The most promising route to filling the information gaps, determining the quantity and characteristics of offensive capability necessary for deterrence, and acquiring the weapons, tactics, and training to deter and defend, is a strong increase in the number of people concerned and informed about chemical matters, both inside and outside the defense community, and an increase in their concern and information.

A. IMPLICATIONS OF THE HISTORY OF CHEMICAL WARFARE FOR A HYPOTHETICAL CHEMICAL/CONVENTIONAL WAR IN THE LATE 1980s

GAY HAMMERMAN

Historical Evaluation and Research Organization
A Division of Data Memory Systems, Inc.
8316 Arlington Bvd, Suite 400
Fairfax, Virginia 22031

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IMPLICATIONS OF THE HISTORY OF CHEMICAL WARFARE FOR A HYPOTHETICAL CHEMICAL/CONVENTIONAL WAR IN THE LATE 1980S

This paper will discuss, first, what the author sees as the key aspects of chemical warfare as they appeared in the only large-scale chemical/conventional war that has occurred -- World War I; second, the author's specific area of research in World War I chemical combat -- the psychological impact on troops of the chemical weapons when they were first used, and the adaptation of troops and commanders to the new weapons; and finally, implications of the World War I experience for a possible future chemical/conventional conflict.(1)

The Central Features of Early Chemical Warfare

The extreme importance of surprise is here suggested as the most significant feature of chemical warfare in World War I. This is said with full realization that surprise is of extreme importance in any military conflict, and that the statement just made may therefore appear meaningless. Nevertheless, it is argued here that surprise was even more important in chemical warfare than it is in warfare generally, and it is suggested that this may be a feature of chemical warfare that is especially important in thinking about any future conflict in which chemicals may be used.

Why should this be so? Why is surprise so important? The answer has to do with the kind of defense that could be created against chemicals. Because of the nature of the agents used in chemical warfare, a relatively effective defense was possible. More specifically, because chemical agents did not destroy inanimate objects like fortifications, and did not tear the human body apart by gross physical forces, they could be protected against by placing a shield between them and the vulnerable areas of the body. Although no protection was perfect, there is a striking difference between the effects of gas in World War I in cases where troops possessed and were using protective respirators and those where they did not.

However, defense was not easy, and this is what made surprise possible, even after the complete surprise of the initial introduction of gas was over. If wearing protective devices had been a matter of an improved helmet or clothing, as easy as the French soldier's taking off his <u>pantalons rouges</u> and putting on horizon blue, the history of chemical warfare in World War I would have been very short. but the equipment that was required to create the barrier between man and chemical was cumbersome, uncomfortable, and seriously hampering to the performance of military tasks. Therefore the barriers were not in place continuously. It was possible to catch enemy troops unprotected. A major purpose of chemical research and development, and of chemical tactics, during World War I, was to do just this.

This constant tension between surprise and protection appears to be the most significant feature of World War I chemical warfare. A second significant feature was the ability of the agents to kill and incapacitate troops without disrupting terrain and destroying structures. This was, at least theoretically, of considerable importance in a war that saw breakthroughs repeatedly thwarted by the difficulty of moving troops over ground cratered by preparatory artillery bombardments. A third feature was the ability of some chemicals to persist in the environment, continuing to kill and incapacitate, thus denying positions and areas to an enemy over a period of time. This capability was extensively exploited by the Germans during the last year of the war.

However, as indicated above, the tension between surprise and protection seems to have been the most important aspect of chemical warfare in World War I, and it will be developed more fully below.

<u>The Possibility and the Burden of Defense</u>

it is hard to think of an incident of chemical conflict in World War I that does not involve the presence, or absence, or quality, of the protective devices. The first that comes to mind is Wilfred Owen's poetic image of the man who did not get his mask on in time, seen gasping, as if drowning, through the eyepiece of a man who did. Another British soldier wrote

> In the early part of April 1915, we were in the trenches opposite Messines. We enjoyed the usual morning and evening "hate"; we sniped and were sniped at; we patrolled and wired and attempted to drain away the superfluous water, and there was much mud and humor and expectancy...[T]rench warfare was not so very different then from what it is now -- with one great exception: There was no gas. And there were consequently no respirators to carry day and night. it is almost impossible now to remember the time when one did not carry a respirator in the trenches....[A]nd yet there we were, imagining we knew what war really was like!(2)

Here are some additional incidents found in recent research:

- British soldiers in early May 1915, urinating on their handkerchiefs, tying them over their noses and mouths, and holding their positions; others, in heavier concentrations of gas, constantly lowering and readjusting bits of veiling and cotton waste that finally disintegrated and left the men gasping helplessly.

- Canadian artillerymen in the summer of 1917, especially those laying guns and setting fuzes, ripping the facepieces off their respirators, knowing they were inviting painful blinding, but, as one of their commanders said, "trained and so disciplined" that an order to support infantry under attack called "for any sacrifice to give an accurate and intense rate of fire."

- A machine gunner named Jackie Lynn in the first gas attack on British troops who set his gun up on the parapet of the trench, did not stop to put on a respirator, fired all during the attack, and was then carried out of the trench on a stretcher, blue and dying.

• A portion of an interview with a 90-year-old veteran of the great Whitsun Monday attack of 24 May 1915:

Q. Was gas something more to be afraid of than other weapons?

A. When we had bunches of new recruits, what we always tried to impress on them was, always look after your respirator.

This man was asked to say whether gas was especially feared, or was more feared than artillery, but his only answer was, "If it was gas, first thing, respirator."

All the respirators devised during World War I had disadvantages as to weight, comfort, resistance to breathing, and limited vision. Artillerymen suffered especially from the vision problems. Because gas was not used very widely in relation to gunshot weapons, there were extensive sectors where gas was not experienced. Under these circumstances, men often discarded their respirators.

Effective use of the respirator required training, and thus much effort went into training. The standard technique was a lecture followed by drill in donning the mask in a chamber filled with low-concentration chlorine. Some men complained that they were not taught how to recognize gas, only how to put on the respirator. Inculcating protective procedures for mustard was especially difficult. Because it was persistent, it was hard to train men to keep their masks on long enough. Because such a high proportion of the casualties were relatively minor and quickly healed, it was hard to make men understand that it could be lethal. At the same time, because of its insidiousness -- that is, because it could penetrate clothing and boots to attack the skin and flesh, and could remain in an area for hours and days, virtually invisible and odorless -- it could evoke exaggerated and irrational fear. Consequently, commanders and gas officers sometimes tried to debunk its horrors and at other times emphasized its dangers. And of course, in World War I there was no protection from mustard for the body, but only for the lungs, eyes, and face. For all gases there was the problem of gas warning; how could one spread the alarm when no orders could be shouted? Banging on shell cases was later supplemented by the compressed-air Strombos horn.

The trenches had to be cleared of gas. Against chlorine there were the "Vermorel" sprayers -- so called because the men squirting sodium hyposulfite to neutralize the chlorine looked like pest exterminators. Fires were tried, systems of canvas fans were tried. Gas-proofing of dugouts was a major problem that was never really satisfactorily solved.

Officers and men complained about the burden of protective measures and complained that they were poorly designed, inadequately taught, and disseminated with inconsistent and sometimes contradictory orders. The physical burden these protective measures put on troops and commanders was heavy.The measures did, however, work, to the extent that gas became a harassing, neutralizing, and area-denying weapon, an adjunct to tactics rather than the decisive offensive weapon it showed promise of being in early 1915.

The Crucial Importance of Surprise

Because the protective measures existed and because they worked, surprise was all-important. Because the protective measures were so burdensome, surprise was possible.

In World War I, of the very few significant tactical breakthroughs that were achieved with chemicals two were achieved on the very first days lethal gas was used, in the Second Ypres attack of 22 April 1915 on the Western Front, and in the attack at Bolimov ten days later on the Eastern Front. This was quintessential surprise -- the unexpected use of a completely new weapon against completely unprepared and unprotected troops.

Both Germans and Allies struggled all through the war to achieve significant surprise with chemicals again. Between 38 and 50 agents were introduced by one side or the other during the course of the war, and behind each new introduction was the effort to circumvent existing protection, that is, to surprise the enemy with an agent against which he was not protected.

In addition to the new agents, there was a constant search for delivery methods that would create a cloud of gas on the target that was dense enough to overwhelm the respirator. The British had some success with the Livens projector, which lobbed containers of gas into the German trenches, and the Germans likewise achieved relatively high fatality-to-casualty ratios with their mortar projectiles, which produced intense, surprise cloud concentrations.

In addition to the myriad agents and numerous delivery mechanisms that sought to achieve technological surprise with the gas, there were surprise tactics. Following are some of the tactical devices that were used by the Germans in an effort to break through enemy protective measures by catching enemy troops without their respirators or striking them in a way for which they weren't prepared.

- Night attacks became standard procedure, primarily in order to achieve surprise.

- In 1916 the Germans began using several waves of gas at irregular and varying intervals -- again, to catch Allied troops without their respirators.

- The Germans introduced smoke mixed with gas to make a light attack look heavier, and then followed this by a genuinely heavy attack while Allied troops were off guard.

An example of a German attack that was especially effective in producing casualties, although insignificant tactically, was one of the last cylinder-created gas attacks, carried out against French troops near the village of Prosnes in the Champagne sector, on 31 January 1917. The gas -- chlorine mixed with either phosgene or chloropicrin and with smoke -- was released in a very high concentration, 60-85 pounds per meter of front, one of the highest concentrations of the war. No attempt was made to hide the fact that a gas attack was to be launched, but effective surprise was nevertheless achieved by

- use of a concentration so heavy that it reached as far as 20 kilometers to the rear in casualty-causing concentrations, catching large numbers of men in reserve positions without their masks;

- carrying out the attack in cold weather (-5 degrees C to -18 degrees C), which reportedly kept the cloud close to the ground and the concentrations high there. Men also apparently had difficulty donning masks quickly in this weather.

- carrying out the attack in two waves, so that many troops had decided the anticipated attack was past and removed their masks when the second heavy attack came.

By late 1917, when the Germans had abandoned cylinder-cloud attacks for gas-shell attacks, they had developed what they called "gas surprise fire" tactics, and, according to an authoritative German source, all other methods of gas fire used in offensive operations were based on this technique. The aim was to hit enemy troops hard with gas before they could complete masking, by firing the maximum concentration of gas possible without any warning. One hundred rounds of light field gun (77mm Krupp) ammunition, or the equivalent (for example, 50 rounds of 105mm. howitzer ammunition) in other ammunition, were fired in the space of one minute. If the Germans thought the target personnel had masked, they first fired Blue Cross shell, which contained arsenic compounds that were not generally lethal but that penetrated the mask to cause tears, sneezing, and vomiting, and made the affected troops rip off their masks, leaving them vulnerable to the lethal phosgene or similar agent in the Green Cross shells that immediately followed.

These are only examples, and do not include Allied tactical innovations, but they show the strong emphasis that was put on surprise in developing gas agents, delivery means, and tactics.

<u>Gas: An Antipersonnel Weapon</u>

Logically, one of the great military advantages of chemical agents is that they kill and incapacitate people without damaging terrain and structures. They were thus, logically, the enhanced-radiation warhead of World War I, and it could be hypothesized that some of the repulsion that they, like the ERW, evoked was the result of this uncanny, seemingly "unnatural" characteristic. Little evidence has been found that commanders deliberately exploited this characteristic. Commanders did not generally decide to try to take a given fortification by gas in order to preserve it for future use. Gas would also seem to have been a possible answer to the problem of counterproductive massive artillery bombardments that alerted the enemy of impending attack and also cratered and churned up the terrain to such an extent as to make it barely passable for attacking infantry. This may have been a significant factor behind the introduction of gas. No explicit mention of it has been noted in the sources, but the first gas attacks did take advantage of this characteristic. On 22 April 1915, there was complete quiet on the day of the attack until 15 minutes before the attack, when a very intense artillery preparation was fired. The absence of a long preliminary attack achieved surprise, which was probably the main reason for it. It also avoided destruction of the terrain. Although a heavy rolling artillery barrage continued, trapping French troops between gas and high-explosive shell, the Germans were not hampered by cratered terrain from exploiting their gap. They were hindered, rather, by darkness and inadequate reserves.

Certainly the one basic problem of the Western Front in World War I was how to break the stalemate of the trenches -- how to achieve a breakthrough when each side was so formidably entrenched and any major attack seemed to require so much preliminary artillery fire that enemy reserves had ample time to reinforce the threatened point, while one's own infantry had to struggle slowly over the smashed terrain. Gas provided a way to flush the defenders out of their trenches without advance warning and without terrain destruction. Even if this was not stated explicitly, it must have been a chief reason for introducing gas. However, once defensive measures had been developed -- and this took surprisingly little time, because surprisingly primitive measures gave a good deal of protection -- gas could no longer be used effectively at the beginning of an offensive to achieve a breakthrough.

Persistence

The introduction of mustard gas in the summer of 1917 marked what one historian has called "a new dimension in chemical warfare."(3) This is true because of mustard's ability to penetrate ordinary fabric and leather to attack the entire skin surface, and because of its persistence. Mustard could cause large numbers of painful burn casualties and cases of temporary blindness -- so many, in fact, that troops tended to forget it could also be lethal if inhaled. It was effective in removing large numbers of troops from the lines as short-term casualties, something that made a difference to the Allies during the German offensives of spring 1918. Its persistence -- for hours or days -- made it useful for denying areas to an enemy.

While it was obviously useful on the defense, mustard was also useful in the offense. By spring 1918, the Germans had fully integrated it into their offensive tactics. Before each of the spring and summer offensives, mustard bombardments were fired for days before the attack, saturating areas on the flanks of the sector through which the attack itself would move, thus denying these to the Allies and causing both casualties and exhaustion from prolonged mask-wearing among Allied troops. Artillery positions were prime pre-assault targets. Once the attack was underway, mustard was used against isolated strongpoints that the Germans did not want to waste casualties in assaulting.

Summary of Tactical Experience

To summarize the tactical experience, lethal chemicals were first used in massive cylinder-produced clouds in preparation for large-scale infantry attacks. These cloud attacks were largely abandoned after about 18 months, certainly as an attempt to create a breakthrough. After that, chemicals were used largely for neutralizing artillery batteries -- a major use -- and disrupting supply operations; for harassing enemy troops and causing attrition, especially among troops massing for an attack; and for denying areas to an advancing enemy, and denying to a defending enemy areas through which reserves and supplies could be brought up. The Germans used mustard effectively in defense in the summer of 1917 and in offense in the spring of 1918 -- in both cases by denying areas to the enemy. Chemicals were also useful in breaking up concentrations of troops preparing to attack.

Casualties and Fatalities

In World War I, the ratio of gas casualties to gas fatalities was extremely high, especially toward the end of the war, when mustard was the principal casualty causer. It is easy to learn that chemicals caused many <u>more casualties in relation to fatalities</u> than gunshot wounds (artillery shells, machine guns, and small arms) did. It is harder to tell how chemicals compared to guns in causing casualties and in causing fatalities: much less gas than high explosive or shrapnel ammunition was used in the war as a whole.(4) Some gasses were much more lethal than others. It is hard to find a common unit of measure for gas and gunshot weapons; the artillery shell is the best one available, since gas as well as high explosives were delivered in this way, but some of the most lethal gas attacks were not produced by shell. All things considered, it is probably safe to say that an average chemical shell produced somewhat more casualties than a high-explosive shell, while producing no more than half the fatalities, and probably fewer.(5)

Large numbers of casualties resulted from failure of troops to use protective devices. It could probably be safely said that virtually all mustard <u>deaths</u> were the result of not using protection.

Psychological Impact on Troops

Then there is the psychological impact of gas on troops in World War I. There are two major reasons why this psychological impact might be greater, and has often been assumed to be greater, than that of other World War I weapons, of which we may take the high-explosive artillery shell as the representative example. First, lethal gas was an absolutely <u>new</u> weapon when it was first introduced, and the special fear of the unknown, plus the panic that may be induced by trying to deal with a situation for which one is untrained, unprepared, and unprotected, might reasonably be expected to add up to an extraordinarily strong psychological impact. Second, gas is often regarded as an inherently insidious and therefore terror-inducing weapon. It can be invisible or almost invisible, it can be odorless -- or in World War I almost odorless -- and it can have delayed effects that show up only hours or even days later. Thus, if a soldier thinks or knows that he has been exposed to gas, or may have been exposed to gas, it is reasonable to think that he might react strongly -- with panic, or with anxiety strong enough to degrade his military performance, to cause him to develop psychologically induced physical symptoms, and to report to a medical station for help that he does not actually physically require.

The following conclusions appear reasonable on the basis of research done thus far:

- The newness of the weapon did cause panic at first, partly because the attacked troops had no protection and no established procedures to follow in dealing with gas; that is, it was both the mysterious nature of the gas and the practical inability to deal with it that caused the panic.

- There were a good many troops who reported for treatment for gas when they were not in fact suffering from gas, although in many cases they were suffering from something else, such as shock or influenza. A 1918 report stated that 80 percent of troops reporting to divisional gas hospitals were suffering from causes other than gas.(6)

- There was not more fear of gas attack than of high-explosive artillery bombardment by men exposed to both.

Instances of Widespread Panic

In discussing widespread panic, this paper will be dealing with unauthorized withdrawals of large groups, that is, division-sized units. Very little has been written about panic in military organizations by psychologists, and this author has repeatedly had combat veterans recommend Stephen Crane's fictional treatment in The Red Badge of Courage as the best source. Those who have experienced or observed panic at close hand generally say that it begins with two or three soldiers who turn and run, and that when a critical mass of men becomes involved, a compulsion to run that seems contagious and almost palpable spreads through a whole unit.

This is what happened when lethal gas was first used. A few men in the front lines turned and ran. Soon the front-line brigades of two divisions were running toward the rear. Over a thousand prisoners who were not wounded and not seriously gassed were captured by the Germans. Hundreds of unwounded men, some gas-injured and some not, but all capable of running kilometers to the rear, did so. The front-line units suffered an estimated 60% casualties, including the prisoners, the gassed, and the wounded. A gap was opened in the Allied line. If darkness had not overtaken the German pursuers, and if they had planned for reserves adequate to exploit such a breakthrough, the stalemate of the trenches could have been broken in April 1915.

The question is why it happened. Was it because the troops were inferior? Was it because the gas was an inherently terror-producing weapon? Was it because the gas was an extraordinarily lethal or casualty-producing weapon? Was it because the troops were unprepared for it?

The only question that can be firmly answered "no" is the first. Contrary to some previous assumptions, the French 45th (Algerian) Division was an elite unit with a fine reputation. The other division involved, the 87th (Territorial) Division, was probably somewhat below average, but since both divisions behaved in the same way, there is no reason to think that the quality of the troops involved had anything significant to do with the panic.

As to the terror-producing characteristics of the weapon, there is evidence of this. The Germans saw some French troops dropping their rifles and moving toward the rear even before the visible bulk of the gas cloud reached them -- the odor must have been extremely strong at that point, and the sight of the approaching cloud terrifying. One panicked soldier also reportedly said to his commander, "General, the bastards have poisoned us," a cry that suggests panic based on the novel nature of the weapon.

At the same time, the gas undoubtedly was extremely lethal, used, as it was, in high concentrations and against troops who had absolutely no protection and absolutely no knowledge of how to minimize the gas's effects. A very rough estimate has been made of about 2,500 gas casualties (of 4,500-5,500 total casualties) in that first attack, with perhaps one-third of these killed or mortally injured. Thus gas in this first attack was probably as lethal as a heavy bombardment of artillery.

However, perhaps the most important factor in the panic was the lack of protection, lack of warning, and lack of a standard procedure to follow. The strongest evidence for this is the fact that only a few days later Canadian troops with the most minimal protection, or none, who were aware that the Germans were using lethal gas, were able to hold positions through gas attacks. Russian troops, attacked on a massive scale just 10 days after the first attack, knew that the Germans were planning a gas attack. The Russians had no protection and took extremely heavy casualties, opening a gap that Germans could have exploited if they had known about it, but the Russians did not panic -- they just died.(7)

There were at least four other instances of widespread panic as a result of gas attacks during the war, and Dorothy Clark has examined all five. She notes that in all of them there was poor gas discipline or none at all, and that in two the troops had no gas masks at all.

Individual Anxiety, Malingering, and Psychiatric Casualties

In discussing the matter of men who reported themselves gassed when in fact they were not, it must be noted that many of these men were probably honestly misinformed about the effects of gas. A US Army censor said, for example, that the "most censorable element" in letters US troops wrote home was "'unwitting misinformation' about gas."(8) It is thus not surprising that many thought they were in grave danger when they were not. It must also be noted, without making moral judgments on the troops involved, that the symptoms of gas -- vomiting, coughing, fatigue -- made it easy to fake. Figures for those reporting unnecessarily as gas casualties have to be looked at in the context of the overall stress of combat, and perhaps especially of World War I combat. Men were reported to stand on their hands in the trenches to invite a foot wound. Men were reported to discharge their own weapons into their legs during an attack. This behavior was not the norm. There seem to have been relatively few cases, at least in the British and US armies. But they did occur. When such a safe and painless way to gain a quick respite from the battlefield as the claim of gassing was available, it would have been surprising if a good many men had not taken advantage of it. It must also be noted that a probably sizable number of men who were mildly gassed refrained from reporting to aid stations because they did not want to appear to be malingerers.

As for psychiatric casualties caused by gas, which is a different subject from gas malingering, there was "gas shock," as there was "shell shock" -- called "combat fatigue" in World War II; that is, there were men who reached an individual psychological breaking point following continuously repeated gas alarms, long hours of wearing masks, seeing other men gassed, and repeated and prolonged illness from mild gas poisoning -- always in the context of the other stresses of World War I combat. An early mild example of flashback following gas attack is reported by a veteran of the first attack on British troops:

> Chloride of lime has a very similar smell to the enemy's gas, and when going to the latrines, men ... caught the unexpected smell of this and for the moment [mistook] it for German gas. It served us all alike. A sudden whiff of this chloride of lime, and our hearts began to thump, and we broke out into a cold sweat. Which proves how much we feared it.(9)

He adds immediately, in parentheses, "This was of course before we had gas masks."

The writer Robert Graves, in his memoir Good-bye to All That, says

> I thought of going back to France, but realized the

absurdity of the notion. Since 1916, the fear of gas had obsessed me; any unusual smell, even a sudden strong scent of flowers in a garden, was enough to send me trembling.

He adds immediately that he also couldn't stand the sound of heavy shelling. "The noise of a car back-firing would send me flat on my face, or running for cover."(10)

And Dennis Winter, a well-regarded popular historian writing now, in his book on life on the Western Front, Death's Men, says, "All men feared artillery. Gas was their other great fear." He gives six pages of examples of shell shock, and expressions of terror and horror about artillery, taken from memoirs of veterans, but only one quotation about gas -- and that one is related to the anxiety induced by repeated gas alarms rather than actual gas attacks.(11) It is true that the amount of gas used in the war was much less than the amount of high-explosive shell used, but the case that gas was as much feared as artillery by men who experienced both is still hard to make convincingly, especially when it is remembered that high-explosive shell was almost always part of any gas attack, or preparatory to it, or following after it, so that men suffering psychiatric disorders often were responding not just to gas but to all the stress of an attack.

A graph from Dorothy Clark's 1959 study offers strong evidence of the connection between intense combat stress and psychiatric disorders. The graph shows a significant correlation between hospital admissions for gas injury and admissions for nervous disorders, and a still higher correlation between admissions for battle casualties other than gas and admissions for nervous disorders. The statistics on which the graph is based are for the American Expeditionary Force in 1918. (See Figure 1, p. 12.)

How Much Fear of Gas?

Then there is the question of just how consciously fearful soldiers were about gas in relation to their fear about combat in general. This has been touched on above, and will be further approached here through a quick summary of about 30 first-hand personal accounts of veterans who had experiences with gas, especially during the earliest attacks in which it was used, and who discussed the emotional reactions they experienced or observed. These accounts are not presented as a proper sample of such veterans. They are simply all that could be found in published and archival materials, plus one personal interview, in a year of searching.

When British and Canadian troops heard about the first attacks, or witnessed the rout of the French troops, they were angry, both at the Germans for carrying out a "dirty trick" and at the French for running. Some officers were worried because they knew they had nothing to use against gas, and men who had experienced one attack feared another, for the same reason; the seeming invulnerability of the weapon caused anxiety. The anger

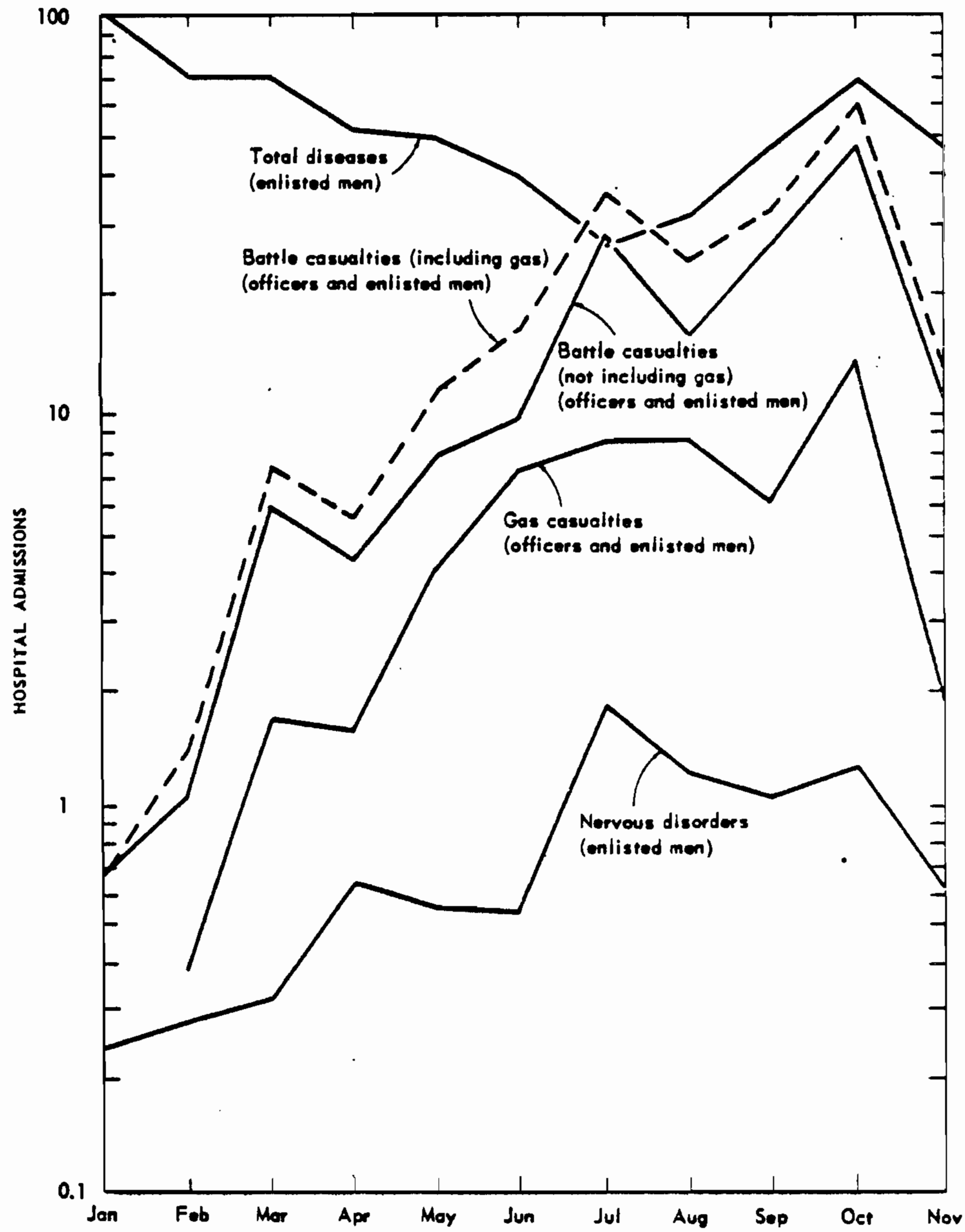

Fig. 1 —Hospital Admissions in AEF in 1918 for Nervous Disorders, Gas Casualties, Battle Injuries, and Diseases

Ratios per 1000 strength per month.

Source: Dorothy K. Clark, _Effectiveness of Chemical Weapons in World War I_, p. 93.

of the men in threatened positions made them more determined to hold their positions or move forward on orders. They responded positively to appeals to patriotism and to the need they perceived not to let down their compatriots or fellow-unit-members in the front lines. Not doing anything, just enduring an attack, was what was hardest. Many felt the impulse to move out, either forward in attack or back in escape. Some officers immediately recognized the chlorine by smell and urged their men to urinate on handkerchiefs, thus using ammonia to neutralize the chlorine, and use them as respirators. Simple respirators -- rectangles of flannel or women's veiling filled with cotton waste and saturated with a neutralizing chemical -- were given to the troops within two or three days, and these not only made a life or death difference in many cases but seem to have played a very positive psychological role. Leadership and esprit de corps are specifically mentioned in several cases as holding a unit together under gas attack, and their role is implicit in other accounts.

If one judges by the number of spontaneous comments made about the appearance of dead and dying gassed men, it was this aspect of gas warfare -- the appearance of the gassed men -- that was most emotionally disturbing to troops. As for their own physical anguish, most of the men say only something like "I was beginning to feel rather desperate," but others describe the sensations graphically. Although there were no widespread panics in 1915 after the first day, there were small local routs of panicked gassed men.

Among men who were themselves attacking with gas for the first time, there was apprehension, and rightly so, because there were accidents with the cylinders before the attacks, and also blowbacks of gas on the attacking troops. There was great disappointment among the troops in the first British use of gas at Loos, because of the friendly troops gassed, the belief that the gas hindered visibility for friendly troops and attracted enemy fire, and the fact that no breakthrough was achieved.

After about 18 months, gas had been basically assimilated into the weapons arsenals of all the warring powers. Reasonably effective protective and warning devices had been developed, defensive procedures had been inculcated by training -- although never well enough to avoid unnecessary casualties. Cylinder-produced cloud attacks had been largely replaced by more precise and controllable -- although less lethal -- attacks with gas-filled shell. Offensive tactics had been developed, with specific techniques for specific missions. The attempt to achieve major breakthroughs through massive gas preparations had been virtually abandoned.

Does this mean that gas had become "just another weapon"? Veterans, like historians, disagree on this, disagree as to whether there was a special fear and horror of gas that persisted and impaired performance above and beyond the casualty-causing capability of the weapon and the degradation of performance that was imposed by protective devices.

Further research is certainly needed, and specifically research carefully designed to isolate the performance-degrading impact of gas weapons in World War I. But on the basis of the evidence seen so far, this writer has to conclude that gas weapons were, basically, assimilated into World War I tactics and logistics, that troops adapted to them -- including mustard after its introduction -- and that gas was not more feared, or more responsible for psychiatric casualties, than the other stresses of combat, of which high-explosive artillery bombardments were probably the chief.

Implications for a Future War

The most important implication of past experience for future war is the great premium on surprise in chemical warfare. If maximum effectiveness is to be gained from using chemicals, then surprise -- of time, place, mass of attack, and weapon -- that is, agent -- must be achieved. It was only when complete surprise was achieved that chemicals had a significant offensive tactical effect in World War I -- in contrast to a casualty-producing, harassing, or delaying effect. If surprise is a key factor in any attack, it is nevertheless even more important in a chemical attack.

In a historical environment in which a wide variety of agents are known, possessed, protected against, and trained against by both sides -- that is, the kind of environment that existed by mid-1917 and which may be said to exist now -- the chief means of surprise sought is logically an agent different enough to break through or around existing defenses. All nations sought such a weapon, as witness the scores of different agents introduced. The Germans, to some extent, found it in mustard. Because of its delayed effects, mustard could not cause tactical surprise and widespread panic. Because of its persistence it was not suited for general, preparatory offensive use. Thus it could not be used to achieve a tactical/strategic breakthrough. But its ability to penetrate clothing and footwear, to attack the whole body, and to make a position or an area uninhabitable were extremely effective for the specific missions they fit. It did circumvent defensive measures, and the Allies were unprepared to deal with it. It would appear that any country that intended to use, or wished to be able to use, chemical weapons in the future would be likely to put a vigorous effort into developing a radically new agent, an agent that circumvents current protective measures, a mustard of the future.

The ways in which chemicals are likely to be used in a future war, on the basis of past experience in chemical warfare, would seem to be these:

- If new, nonpersistent agents were available, these would probably be used in mass against the first echelons of defending troops as the first strike of a massive combined offensive;

- Artillery/missile positions would be prime targets for combinations of persistent and nonpersistent agents;

- Persistent agents would be used to isolate segments of the battlefield, limiting the capability of a defender to bring up reserves;

- Reserve troop concentrations in a defender's rear could expect intense chemical bombardments, with new agents if possible;

- Harassing chemical bombardments at irregular intervals and in varying strengths might well be used against holdout positions, for attrition and to keep defenders in protective gear.

As for the reaction of troops attacked with chemical weapons, if World War I is a guide, troops who are unprepared and unprotected may well panic and collapse as units. Protection and training were the keys to unit cohesion and effectiveness in the face of gas in World War I. Protection that is not reasonably comfortable and does not permit good visibility will not be worn for long periods of time. The chief threat of chemicals to positive troop behavior, on the basis of World War I, is not so much the mysteriousness, or insidiousness of the weapon, but the danger that because it is new, unexpected, and has not been trained for adequately or at all, men will panic through not having a thoroughly inculcated procedure to follow.

In 1915, it was quite remarkable how quickly, following the first use of gas and the first panic, troops adapted to the new weapon, with only minimal protection and instruction. Just eight square inches of wet flannel, the instruction to keep high in the trench rather than lying down, and a few encouraging or challenging words from a leader made a great deal of difference.

It may be appropriate in this connection to quote General Sir John Hackett:

> Men adjust quite quickly, even to the appalling conditions of the battlefield, particularly where there is a job to be done which they know how to do and for which they have the right tools, and above all when they do it under competent direction in the company of their friends.(12)

FOOTNOTES

1. Hereafter, the term <u>chemical warfare</u> will be used, and will be understood to mean chemical/conventional warfare, i.e., warfare in which chemical and conventional weapons, but no nuclear weapons, are used.

2. S.J.M. Auld, <u>Gas and Flame in Modern Warfare</u>. New York: George H. Doran, 1918, pp. 9-10.

3. Dr. Brooks Kleber, conversation with author, 15 December 1983.

4. This statement should not be taken to imply that chemicals were not considered effective. In fact, as the war went on, a higher and higher proportion of artillery shell had chemical fill, rather than, or in addition to, high-explosive fill. Nevertheless, the average soldier in the war was exposed to much more high-explosive fire than gas, and many went through months of combat after gas was introduced without experiencing gas at all. It is hard to quantify the relationship of gas used to other weapons used. As a rough measure, Dorothy K. Clark (see note 5, below) states that, although about 80 percent of all gas used was delivered by artillery shell, only 4.5 percent of all artillery shells fired had chemical fill. By the end of the war, the proportion was nearing 50 - 50, but this does not change the experience of the average soldier during the war.

5. Sources consulted on comparison of gas and gunshot casualties and fatalities include Dorothy K. Clark, <u>Effectiveness of Chemical Weapons in World War I</u>, Staff Paper ORO-SP-88. Operations Research Office, Bethesda, Maryland, 1959, especially pp. 101 and 109-110; Albert G. Love, <u>War Casualties: Their Relation to Medical Service and Replacements</u> (Army Medical Bulletin No. 24), Carlisle Barracks, Pa., 1931; and H.L. Gilchrist, <u>A Comparative Study of World War Casualties from Gas and Other Weapons</u>, Chemical Warfare School, Edgewood Arsenal, Md., 1928.

6. US Army Medical Department, <u>The Medical Department of the United States in the World War</u>, Washington (Government Printing Office), 1926, Vol. XIV, p. 830. The wording of the report does not make it clear what proportion of soldiers were considered to be simply malingering.

7. From what is known of Russian military behavior in general in World War I, there may well have been a national cultural component in the Russian response to this gas attack.

8. Clark, <u>Effectiveness of Chemical Weapons</u>, p. 90.

9. W.A. Quinton, unpublished memoir, Imperial War Museum, p. 52.

10. Revised 2d edition, Garden City, N.Y.: Doubleday Anchor Books, 1957, pp. 267-268.

11. Penguin Books, 1979, p. 121.

12. <u>The Third World War; August 1985</u>, reprint, New York: Berkley Books, 1980, p. 20.

B. PRELIMINARY OBSERVATION ON THE IMPLICATIONS OF HISTORICAL EXPERIENCE FOR FUTURE CHEMICAL WARFARE

VICTOR UTGOFF

Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, Virginia 22311

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Preliminary Observations on the Implications of Historical Experience for Future Chemical Warfare *

Victor Utgoff
Institute for Defense Analyses

Background

I knew that my fellow speakers were going to talk a lot about chemical warfare during World War I, so, by and large, I'm going to bypass that subject and talk about what happened in the inter war years and during World War II. Given the limited time available, I'm going to present what I think are the highlights of my historical research on CW during that era--the things that I thought were particularly surprising about chemical warfare.

Origins of U.S. Public Attitudes Toward CW

The first surprise I encountered in my research is that popular attitudes toward chemical warfare in the U.S. were apparently set after World War I, not during it. Chemical warfare, after all, was one horror among many during World War I--unrestricted submarine warfare, atrocities in Belgium, the horrors of trench warfare, and so forth. Official propaganda campaigns shifted back and forth, first talking about the horror of what the Germans were doing, then being quiet about it because they didn't want to scare people too much, and finally presenting Allied chemical warfare as a triumph of Allied industry in being able to match the Germans. After the

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war, however, CW was made the horror of horrors by the U.S. chemical industry. American chemical manufacturers were looking for support for an embargo on chemical imports. They argued that a strong National chemical industry would be essential in wartime to guarantee our preparedness for chemical warfare. In order to gain support for a protective embargo that would help the American chemical industry, they painted lurid pictures of the future of aerochemical warfare--large aircraft bombing cities with gas bombs, whole countries being destroyed. A multiyear publicity campaign was carried out--speakers to Kiwanis clubs and veterans organizations, lots of articles published. The details are in Frederick Brown's book--Chemical Warfare, A Study in Restraints.

The result of this publicity campaign was to single out chemical warfare as a natural topic for talks on arms control. The discussions and publicity devoted to chemical warfare during the Washington Arms Conference, the first of several inter war conferences that took up the question of chemical warfare, set public opinion even more firmly against it. The Secretary of State, in order to insure that he got ratification of whatever treaty resulted from the Washington Arms Conference, formed an advisory committee of a number of distinguished Americans, including General Pershing. This committee debated the future of chemical warfare and the importance of arms control for chemical warfare.

It accepted, without apparent reservation, the most speculative projections of the possibilites for aerochemical warfare and argued that the U.S. should insist on total abolition of chemical warfare. The treaty ultimately produced by the conference did just that, over practical objections by both Britain and France that there were no measures to insure compliance.

Among the people who participated on that advisory committee was Franklin Roosevelt. I point him out because I think he is the man more responsible than any other for the fact that chemical weapons were not used in the second world war.

After the Washington Arms Conference, the Army, which was predisposed not to like chemical weapons to begin with, made repeated attempts to snuff out its Chemical Warfare Service. They used that arms control agreement as a basis for not putting ever-scarcer funds into preparations for chemical warfare.

Basis for Military Attitudes Toward CW

The second point particular of interest for me in my historical review was that professional military attitudes on CW were generally negative, before, during, and since World War I. These, I think, are the main reasons: First of all, the purpose of warfare is generally to defend or capture civilian populations, not to kill them. CW was seen as a lot harder for civilians to avoid than conventional warfare. The increased indiscriminate threat of CW is held against the military by the civilians. Military service is an honorable profession, and the support and honor to the military is diminished when they adopt styles of warfare that threaten civilians. Second, the honor of battlefield combat is diminished to the extent that the difference between victory and defeat doesn't correlate with valued physical and mental capabilities. If your technical proficiency in delivering aerosol spray determines the difference between victory and defeat, that is not so honorable as if it were a matter of fast thinking, good physical capabilities, good training and so forth. Third, CW vastly complicates warfare which the professional military is certainly against, unless, of course, they can get a tremendous advantage for use of CW. Finally, the psychological burdens of CW seemed enormous. I make this last argument on the basis of some things that were presented in Frederick Brown's book. He tells about the appearance of gas fright, and the necessity of having extra MPs behind the lines to keep the troops in their positions.

Comparability of Today's Strategic Nuclear Threat and the Strategic Aerochemical Threat of the 30's

The third point of interest in my historical research was the discovery that, in the interim period between the wars, the public saw a strategic threat in large scale CW attacks that is similar in some ways to the public's sense of the nuclear threat today. The strategic threat of the twenties and thirties was airpower, coupled with chemicals. Douhet, Mitchell, and others publicized the potential of airpower and the European powers began to see a serious vulnerability to air attacks. In the mid-thirties, there was talk about Britain being open to a military attack--from the air--in a way it had never been before. There was enormous public interest in aviation generally--Lindbergh's flight and a lot of other firsts. The possibility of large chemical attacks with aircraft was publicized not only by reports of the advisory committee to the Washington Arms Conference, but by people like H. G. Wells, who talked about the destruction of large cities by strategic bombing with "permanent death gas"--(I'm not sure what other type of death there is)--in "Things to Come."

The advisory group to the Washington Arms Conference told their story in terms very reminiscent of those used today to discuss nuclear warfare: "Any use of gas would escalate to all-out gas warfare." "Gas bombs would depopulate large sections of the country." "Gas warfare could threaten all that has been gained during the painful centuries of the past." The language was very lurid.

Finally, as Hitler and Mussolini built up their armed forces, they placed great emphasis on creating air forces.

These were the modern weapons; this was the way you demonstrated that you were really with it in terms of having a powerful military force. In short, aerochemical attack was the strategic threat of the twenties and thirties.

Use of CW in the World War II Era

Ethiopia

Now, I want to talk a little about the use and non-use of CW in the period around World War II. The Italian air force used its new air arm to make aerochemical attacks in Ethiopia in the mid 30's. It's notable that Ethiopian appeals for help were discounted, reminiscent of the way the world is not paying a great deal of attention to the CW attacks in Afghanistan and Southeast Asia. Admittedly, the situation is somewhat different.

Britain's Anthony Eden made a very impassioned call to do something about Mussolini's gas attacks in Ethiopia. He argued that if the world ignored violations of the Geneva Protocol, international agreements in general would be worthless. The League of Nations did try to come to the aid of Ethiopia, but only after a long delay. The sanctions imposed by the League were not the most effective that could have been employed, and they were very quickly lifted after the Ethiopians were defeated.

China

The Japanese army experimented with chemical warfare in China, and saw mixed results that did not impress the highest command levels of their army. There were some innovative uses of CW by the Japanese in their China campaign. For example, the Japanese bombarded certain areas behind the Chinese lines, and then made attacks to drive the Chinese through the gas contamination that had been created.

China complained to the League of Nations, but again the response was very weak. Invitations were made to selected governments to report on whether or not they thought chemical weapons were being used in China. After Pearl Harbor, President Roosevelt attempted to aid China by threatening retaliation against the Japanese if the attacks continued. He did this in June 1942, and again in June 1943. The Japanese ignored these threats until early 1944, and there were reports of use by the Japanese in China through mid-'44. There are some indications that when Roosevelt threatened retaliation but didn't do anything when the attacks continued, the Japanese discounted his threats to use chemical warfare. The President, in effect, bluffed and got called.

Other CW Use

Finally, there were isolated incidents of CW use in the Polish defense of Warsaw, and Japanese troops used chemical weapons individually in desperate circumstances. There were however, no large scale uses of CW by the Japanese against the west, and none of the individual uses of CW was authorized at high command levels.

Non-Use of CW in WW II

With respect to non-use, I thought it would be interesting to go through the various situations that arose in World War II where either the decision was made to use gas, or where one could have expected such a decision and for some reason it didn't happen--situations where it was logical to consider the use of gas. I will summarize the main features of these situations, as I see them.

France Against Germany - 1940

France was considered one of the best prepared to use CW, and you might have expected the French to try to stop the German blitzkrieg in 1940 with chemical weapons. The French had maintained an active CW R&D program. They appear to have had adequate stocks of chemical weapons. They had taken extensive CW defensive measures as reflected in the gas defenses incorporated in the Maginot Line.

Blitzkrieg looks particularly vulnerable to CW. The Germans certainly thought it was. In blitzkrieg warfare, the attackers have to travel light and move fast. They can't afford to maintain a CW defensive posture, with its elaborate procedures, heavy logistics, and debilitating protective clothing.

The Germans understood the possibility of French use of CW, both tactically and strategically--and the Germans didn't have an adequate civil defense. They gambled that the French would abide by the Geneva protocol, which the French, the British, and the Germans had reaffirmed in 1939, after Germany's attack on Poland.

In any case, the French high command didn't understand blitzkrieg and thus they didn't appreciate its vulnerabilities. By the time the French knew that they were in trouble, the picture was terribly confused, and my own guess is that it would have been esentially impossible for them to use CW in the ways they had probably planned on using it--in relatively static situations.

Finally, as far as use of gas at the strategic level is concerned, it looks like the French were afraid of strategic air attack, with or without chemicals. They attempted to restrain British bombing of German cities early in the war. In fact, at that point in the war, both sides seem to have had an agreement that bombing of cities was out of bounds. (Question: on the previous point you said that Germans were gambling--is that your impression, or in doing historical research did you come across evidence to indicate that they explicitly examined the possibility? Answer: I believe I saw evidence, but I can't put my fingers on it right now.)

Britain Against Germany - 1940

The second non-use situation of interest occurred as Britain faced the possibility of a cross channel invasion in the late summer and fall of 1940. Britain was surprisingly well prepared for tactical and strategic use of CW. The British also maintained an active CW R&D program, partly in cooperation with the French. They had activated standby production of chemical weapons in late 1938. It looks like they would have had enough CW weapons available in time for the invasion of Britain. Their troops were reasonably trained; although they had lost a lot of gear at Dunkirk, they still had a fair amount of CW defensive gear available.

A massive CW civil defense program had been initiated prior to Britain's getting into the war. Gas masks were available for all vulnerable citizens. 750,000 beds had been set aside for casualties from air attacks.

The British bomber force was growing. Bombs and spray tanks for delivering chemical attacks by air were available. In sum the British were quite well prepared to use CW against a German invasion.

In addition, the British viewed CW as likely to be very effective against beachheads. In the work I've done, I've tried to analyze why chemical weapons might be particularly effective in each one of the tactical situations I've looked at. In this case, CW looks effective primarily because it would slow the invader's race to get ashore. A landing against a large land mass tends to be a race in which the attacker picks a particular landing point and then the defender scurries to concentrate his defensive troops there.

CW can be delivered in high concentrations against the invader because he is initially concentrated in his ships and on a small beachhead, and can't maneuver away. The invader already faces a very tough logistics operation in getting his troops, equipment, and supplies ashore. CW attacks add to that problem a need for debilitating individual CW protection, for extra shelters, for decontamination, extra materials to be carried, and so forth. In addition the invaders' ships are vulnerable to the attack.

The British anticipated a tactical situation in which CW would be extremely effective. They had no particular fears of political repercussions against Britain from allies. Though U.S. opinion was important we weren't in the war yet, and neither were the Russians, and France was out of the war. The British had reaffirmed the Geneva protocol, but their backs would be to the wall and potential future allies would probably understand.

The conclusion that I draw is that Britain would not have been deterred in such dire circumstances from initiating chemical warfare. Britain was prepared to use chemicals against an enemy they credited with a chemical capability, because of the tactical advantage CW afforded. I have to add that the British sense of the dangers of aerochemical retaliation tended to be diminished by two views. First, they felt that HE was a bigger threat against cities than chemical weapons. Second, to the extent that they had experience with sttrategic air attacks--and they were getting plenty of experience--they had found that its destructive potential wasn't nearly as great as they had initially thought.

Apparently, Churchill did decide in favor of CW for use on the beachhead if a successful conventional defense were in doubt.

Soviet Union Against Germany - 1941

The third non-use situation I examined was the possibility of CW use by the Soviet Union to defend against the German invasion of Russia in 1941. Though the Soviet Union had reaffirmed adherence to the Geneva Protocol, these were desperate times.

The Soviet Union was seen as well prepared. It had well developed, modern chemical forces integrated into its armed forces. This, by the way, was also a surprise to me. Soviet CW preparations of the comprehensive character that we talk about today have existed since well before World War II.

At the time of the German invasion, every Soviet regiment had a chemical platoon, every division had a chemical company, and each army had a motorized battalion of specialized chemical troops. Separate CW training academies had been established in the early 1920's.

The new Red Army wanted to adopt modern styles of warfare and didn't have any difficulties considering the use of chemical weapons. There was a well developed CW doctrine by 1928. A cooperative highly secret R&D program for CW was underway with the Germans in the late 20s and early 30s. The Germans built at least one chemical agent production plant for the Russians, and a wide variety of CW weapons were developed.

During the inter war period, some political leaders in Russia had argued for a chemical program that would put the Soviet Union ahead of the U.K., France, and the U.S. in chemical warfare capabilities. According to Soviet chemical officers of the World War II period, the military value of CW was regarded as beyond doubt.

The active constraints on the progress of the German army into Russia were apparently imposed by poor lines of communication. In order to provide the volume of supplies German forces required, railroads had to be used. This required conversion of the gauge of Russian rail lines to standard European gauge, which was very time consuming, particulary under wartime conditions. The Germans ended up using transloading facilities which became bottlenecks. Some trains took weeks to transload. These transloading points would have been very lucrative targets for chemical attacks.

There were also bottlenecks at the river bridges, with masses of German infantry trying to get across. The ferrying operation moving masses of troops and supplies across the Dvina River might have been a very lucrative target for CW attacks.

As in their campaign against France, the Germans gambled that they could shatter Soviet forces before chemicals could be used. It's hard to tell why the Soviets didn't use chemical weapons. A number of reasons are given. The chief chemical officer for a Soviet army reported that the primary reason for not using chemical weapons was that retaliation would have caused greater disorder both in the army and in the rear areas. Also, by this time the Soviets were looking for assistance from President Roosevelt, and it had to weigh on their minds that this man was violently and publicly opposed to the use of chemical weapons.

Japan Agaist the U.S. - 1944

Japan, facing the Marianas campaign, was in another back-to-the-wall situation. The Japanese saw that when the U.S. gained a foothold in the Marianas it would be able to bomb the Japanese home land with land-based bombers. They saw the battle for the Marianas as the decisive battle of the war. The Army general staff argued that no defensive means should be left untried and recommended the use of CW against the U.S. "naval striking force." I take these words to mean hitting our invasion fleet as it attempted to make a landing in the Marianas.

CW might well, for the reasons I gave in talking about the potential invasion, have defeated the first U.S. landings. That would have upset the Allies' time table, until they had achieved the CW readiness necessary for attacking whole islands with chemicals or landing successfully against a CW attack. There would have been value for the Japanese in such a delay. They had suffered the loss of a number of the air complements for their carriers. They were trying to rebuild their naval aviation force as rapidly as they could, and a six-months-to-a-year breathing space might have made a difference.

Japanese readiness for initiating chemical weapons against the Allies was spotty, however. They had done some R&D, had established CW training schools, and they were manufacturing CW munitions. They did have some protective equipment for their armed forces, but generally they tended to have higher readiness in the armies opposite the Soviet Union and lower readiness against forces in the Pacific, in part because the U.S. had indicated that it wasn't going to employ CW.

Improving their CW readiness to the point where they could use chemical weapons to advantage in the Marianas would have required the Japanese to do some training, and would have required bringing a substantial amount of material forward from the home islands. By this time shipping was becoming unreliable because of U.S. efforts to interdict Japan's sea lines of communication.

Finally, the Japanese had started a civil defense program in 1940, which was to give masks and CW training to all threatened Japanese civilians, but the program was very poorly implemented. The government trained a few people, and these were supposed to pass their training to others. The government did not follow up on this training, however, and didn't come close to providing masks for everyone.

The general staff recommendation to initiate CW against the Allies went to General Tojo. I asked myself, "How might he have evaluated it?" Certainly, the long run prospects for a CW war with the U.S. must have looked bleak. The Japanese appreciated our chemical production capabilities. General Tojo must also have known that if we ultimately got into the Marianas, despite Japanese use of CW, then the kind of strategic retaliation the Japanese would see would involve not just HE but also CW bombing.

The Emperor was personally opposed because he feared strategic retaliation. General Tojo decided against CW, and then he did something that seems amazing--he essentially disarmed the Japanese Pacific forces as far as CW is concerned. There is a reference in Brown's book to a Japanese officer who said of this action that it posed no danger--"we knew the U.S. was not going to use CW."

Germany Against the Normandy Invasion

The Germans considered using CW in their defense against the allied invasion of France. German CW preparations had been uneven, but they did have an unrecognized nerve gas advantage in the form of over 10,000 tons of Tabun. One can argue about whether or not they had the air force necessary to deliver CW attacks against our beachheads. I believe that they did, at least for the modest number of chemical attacks that would initially have been necessary to make a shambles of our landings.

The Germans had been against gas warfare, as Hitler and his staff saw Germany to be in a vulnerable central position. The Germans also saw their style of warfare as vulnerable to CW. Material shortages had also limited CW preparations. When decisions had to be made as to where scarce materials should go, they were generally made in favor of weapons that would be used, rather than in favor of weapons that might not. Toward the end of the war, the Germans apparently even shut down nerve agent production for lack of raw materials.

General Oschner, who was head of German CW troops in World War II, said that gas defense was considered for defense of the Atlantic Wall. He argued that all means of defense promising any chance of success had to be considered. He stated that contamination of beach areas would have rendered them impenetrable until decontaminated. "Individual results could not have been foretold, but they definitely would have been in our favor." The Allies saw these possibilities. Allied forces went ashore with respirators and impregnated clothing, and had made backup preparations.

According to Oschner, the German decision not to use CW wasn't made because they weren't fully prepared for allied CW retaliation against German cities. Oschner states that there were plenty of gas masks, and there was a fair amount of shelter for their civilians. Rather, he states that they saw allied CW retaliation as an intolerable burden for German industry, and the western lines of communications that led to the Atlantic Wall. Brown sees Allied air dominance the primary reason for the Germans' decision not to use CW.

Germany at the War's End

Germany apparently considered CW again near the end of the war. Hitler is reported to have agreed to a proposal by Goebbels to withdraw from the Geneva protocol and initiate CW. This would have been consistent with Hitler's refusal to halt some CW programs. Albert Speer had tried to get CW production cut off and had been refused permission to do so.

Hitler raised the subject of CW initiation at a headquarters situation conference with his military staff. He speculated that the Allies would accept German CW use because they wanted the Russians stopped. Hitler got no support from those attending. Nonetheless, Brown says that Hitler appears to have ordered CW initiation, but that he had lost the absolute authority needed to push implementation, and that is why CW was not used in Nazi Germany's final moments.

Allies Against Japan - 1945

Finally, there was a high-level attempt to plan for CW initation by the Allies, should the invasion of Japan prove necessary. CW preparations were somewhat spotty. The U.S. had produced agents and equipment in fairly large amounts but CW material deployed forward in the Pacific theater was inadequate, scattered, and deteriorating. Individual training and organization was deficient and there was a scarcity of chemical officers. A lot of preparation would clearly have been required.

Nonetheless, while President Roosevelt had been strongly opposed to CW, a number of things were shifting U.S. public opinion toward favoring the possibility of CW use. The public was shocked by the high casualties in the island campaigns. Press articles in the U.S. began to suggest gas as likely to be particularly effective against the type of dug-in defenses that the Japanese were employing. When President Roosevelt died and President Truman took office, the issue of CW initiation seemed open again. President Truman was not known to be particularly opposed.

The question was how to end the war. While many people today have the notion that the atom bomb must have been seen as a clear show stopper, that is not the way it appeared at the time. The Army in particular thought that an invasion of Japan would likely be required; Army leaders noted that the Germans had fought to the very end. The Army also said that a large number of casualties were possible. Casualty estimates varied considerably, but Truman said in his memoirs that Marshall estimated the potential loss as high as half a million American lives. General Stillwell, commander of the ground troops in the relevant theater, and General Marshall, Army Chief of Staff Corps, saw the tactical use of gas as likely to save American lives. Marshall argued that there was substantial tactical value against dug in defenses, particularly in the rough Kyushu terrain.

Japanese use of CW to oppose the landings was rated as at least possible. Thus, Generals Marshall and Stillwell were talking about using it against an opponent that, at least at the tactical level, would be retaliating and might initiate CW themselves. General Marshall argued to Admiral Leahy, who was President Truman's military advisor and, in effect, the chairman of the Joint Chiefs of Staff, "Why not initiate, if we are going to go to all the trouble of preparing for retaliation against the possibility of Japanese use?".

General Marshall then started the ball rolling for a decision to prepare for the U.S. initiation. However, he encountered quite a number of delays. In trying to piece together the implications of the memos that flowed back and forth to Admiral Leahy at the White House, the impression I get is that the Navy and Admiral Leahy essentially sandbagged Marshall. They appear to have dragged out the CW initiation question to the point where there was no joint decision to recommend CW use to President Truman prior to his sailing for Potsdam. The joint meeting at which the decision was supposed to be made took place on the day that the President left. Thus the opportunity for consultations on CW initiation with our Allies was missed, and without authority from the highest political levels of the Allied governments, it would have been impossible for Marshall to put in train all the CW preparations that would have been needed.

Concluding Remarks

Now, what can we make of all this? It says implications in the title for the talk, but I haven't really sorted them out yet. I've been busy scratching up the data. Nonetheless, one of the things that impressed me most in my study of the history of CW is that chemical warfare at the operational level is amazingly complex. A lot of this came out of the reading I did on World War I. Pigeon cages needed CW protection. Masks were needed for mules and horses. Drills of all sorts were required. Special procedures had to be developed for cleaning field telephones, because their electrical contacts rapidly corrode in chemical environments. Then, of course, frequent inspections were required to make sure that telephones got cleaned, protective equipment was ready, and proper procedures were understood and followed. Just because procedures exist, even if the troops know them, doesn't mean that they are going to be followed. I don't think that we really appreciate how complex chemical warfare at the operational level would be today, and I don't think that we are going to appreciate the complexities until we get to large unit exercises for very extended periods of time where all the necessary combat evolutions are attempted, including logistics operations.

The second implication I see flowing from the historical record concerns public attitudes toward CW. Attitudes toward chemical warfare seem to be very broad, very deep seated, long-standing, and very negative. We may not appreciate just how deep seated these attitudes are. The public debates on CW stretch over 60 years, and at numerous times during this long period there have been arms control efforts and Congressional discussions of CW questions that have tended to reinforce the negative atitudes that came from prior discussions. Public attitudes toward CW have been reinforced for a very long time.

The third thing that I found interesting in my historical review, is that verification of CW arms control agreements has been an issue all the way back to the Geneva Protocol. The negotiations that led to the Geneva gas protocol started out as a bid to restrict commerce in chemical agents. This effort at a more comprehensive limit on chemical warfare foundered on the argument that it would be impossible to tell legitimate from illegitimate commerce in chemicals.

General Marshall's attempt to raise the possibility of CW initiation with the Allies at Potsdam also underscores an important point. If we are going to fight as part of a coalition, we must pay attention to the guys who are going to fight with us. This suggests we should not adopt a new CW policy without first getting our Allies' cooperation.

Finally, history suggests that deterrence of CW through the threat of retaliaton in kind is a very messy concept in practice. If we look back at the situations I've pointed out, it looks like the U.K. would not have been deterred from the use of chemicals by the retaliatory capabilities which they credited to the Germans. If a German invasion had been attempted, the U.K. would have been in a desperate situation in which tactical use of CW might have been its salvation. Germany, at least at the highest political levels, may not have been deterred from initiating CW at the very end of the war. Finally it doesn't look like the U.S. was completely deterred either. We thought about using CW against the Japanese despite our expectations of significant retaliation at the tactical level.

While the threat of retaliation in kind for CW attacks may be messy, there is no doubting the deterrent value of the ability to retaliate. My look at the history of CW in the World War II era suggests that every potential and actual initiator of CW took his opponent's estimated CW retaliatory capability into account. In some cases the possibility of retaliation appeared to be the dominant factor in determining the CW use decision.

C. SOVIET CAPABILITIES AND DOCTRINE FOR CHEMICAL WARFARE

DR. ALLAN S. REHM

Foreign Systems Research Center
Science Applications, Inc.
McLean, Virginia

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Introduction

The open Soviet military press does not discuss Soviet chemical warfare doctrine and programs in any detail. Except for the case of nuclear war, the Soviets assume in their writings that the opposition will initiate use and the Soviet declared mission is defensive. Soviet chemical troops are to be fully prepared for enemy use of chemicals at any time, and training of all troops for operations on a chemical battlefield is thorough. Soviet offensive use of chemical warfare in a non-nuclear war is a highly speculative matter.

Soviet military leaders probably believe they can win a conventional war in Europe, without employing chemical weapons, although there are situations in which chemical munitions would be the preferred choice against certain types of targets. They appear to believe there is some possibility NATO will make first use of chemicals despite statements to the contrary. They consider it likely NATO will escalate to nuclear warfare if it is losing a conventional war. The Soviets probably estimate that their first use of chemicals might speed up NATO decision processes on possible first use of nuclear weapons or encourage a unilateral decision to do so by the U.S. This concern could serve as either a deterrent or as a rationale for nuclear preemption by the

Soviets.

This paper is a discussion of a number of the considerations the Soviets could be expected to take into account in a decision on whether or not to use chemicals in a non-nuclear war. Capabilities, general principles of operations, and past experience which bear upon an assessment of this question are each considered briefly. The paper concludes with a hypothetical view of the chemical/conventional battlefield of the late 1980s. Based on my understanding of Soviet concepts and operational art, I do not expect much change in Soviet chemical doctrine in four or five years.

1. Soviet Objectives

The ultimate Soviet objective is a world under communism with the USSR as the leader in effective control. Communist doctrine asserts world communism is inevitable, but the time of achievement is unspecified. The Soviets would like to achieve this goal without war. They probably hope that gradual expansion of their sphere of control will lead to pressures resulting in internal revolution in capitalist states and the eventual collapse of the West.

War with capitalist countries is considered to be a possibility deserving serious preparations and expenditure of resources. However, Soviet leaders undoubtedly want to avoid or limit direct conflict and avoid strategic nuclear exchanges if their goals can be reached otherwise. Should strategic exchanges occur, the Soviets want to emerge as the dominant power with a capability for economic recovery and reconstruction. But the destruction from intercontinental nuclear attacks might so weaken both powers that third countries (e.g. China) could gain dominant positions. The Soviets like neither this element of uncertainty and risk nor the losses which they would probably sustain. I think the Soviets have compelling reasons to avoid all-out nuclear war, but they sometimes point out the advantages of their centrally-controlled society over Western society should such a war occur.

2. Conventional War and Chemical Warfare

Conventional war is a possibility in the Soviet view, but for many years the Soviets have asserted that the probability of escalation is high, so high that at times they have appeared to consider it almost inevitable. They have never given much credence to the possibility of limited war as defined in U.S. policy statements, for example, flexible response.

The Soviets' public references to their chemical warfare capabilities imply a defensive mission. Instruction and training in defensive measures is extensive. Much of their equipment is designed for use in a contaminated environment. Defensive equipment is held throughout the Army. I have been told that some equipment designated as defensive is potentially dual purpose and could be used offensively (I have not had the opportunity to see evidence from which to assess the validity of these claims).

To stress the importance of the chemical threat to troops, Soviet training includes use of diluted lethal agents. The training seems to be for defensive operations. Offensive use of chemicals in older exercises either followed or was concurrent with use of nuclear weapons. If every unit were trained for offensive operations the probability of detection would be high. But if such training were reserved for selected units detection would be difficult. Thus, while I have no direct evidence, I cannot rule out the possibility of training for offensive use. Our assessments of Soviet intentions to use chemical weapons in a non-nuclear war are based on judgment, general knowledge, and analysis of isolated facts rather than on explicit evidence.

To my knowledge, the Soviets' first use of chemical weapons during a war in Europe has never been suggested in their literature. Such a statement would be a propaganda blunder unlikely to occur. Nothing is published without extensive censorship. Thus, everything published is "official." Because publication implies official approval in their society I believe they sometimes give too much credence to unofficial U.S. writings.

3. Soviet Discussion of Chemical Warfare

Discussion of chemical warfare in Soviet open literature seems to have been most extensive in the 1960s when CW was included in the term "weapons of mass destruction," along with nuclear and bacteriological weapons. Recent discussion has been centered much more on nuclear weapons with the intent of inducing the West to curtail deployment of theater nuclear systems. The connection in Soviet minds of chemical weapons with other weapons of mass destruction should not be ignored. Decisions on chemical options are probably not made in isolation. If chemical warfare is considered, nuclear options are probably being considered too.

The Soviets follow Western writings on every military topic and comment on U.S. debates such as procurement of binary weapons. They are aware of U.S. concern over whether they will use chemicals offensively in a conventional war. Concern for Western debate is probably one of the reasons for limitation of discussion in the Soviet press.

Soviet writings have long portrayed the U.S. as posing a major chemical threat. Seemingly every mention of chemicals in U.S. literature is noted by the Soviets and interpreted from a worst-case viewpoint. The majority of Soviet troops probably believe in this threat. They are preconditioned to accept statements by their leaders during a war of U.S. or NATO first use. I think the Soviets have a real concern about justifying use of chemicals to their troops. They want them to believe in the justice and righteousness of their cause. Furthermore, they would want to give some explanation for having to operate in the restrictive conditions imposed by protective gear. At the same time, the leadership could probably induce troops to believe almost anything through control of information flow.

The views of the USSR's political leaders are shaped by what the military (in practice, the General Staff) tells them regarding military affairs. Their views on U.S. chemical capabilities probably reflect those of the General Staff. How realistically does the General Staff assess U.S. capabilities? Open evidence suggests Soviet military commentators overestimate U.S. capability, and there is some possibility leaders may also.

Assessing the Soviet leadership's view requires interpretation of indirect references, subtle nuances, and surrogates when trying to decide whether offensive use of chemicals in a non-nuclear war would be authorized. I do not known if there are circumstances in which authorization would be predelegated to field commanders or at what level of command. I suspect there might be, but little can be asserted with confidence. Perhaps such doubt is a Soviet objective.

4. A Weapon of Mass Destruction

The Soviets use the term "weapons of mass destruction" to describe nuclear, chemical, and bacteriological weapons as a group. Writings in the 1950s and 1960s usually implied that escalation to nuclear war was nearly inevitable. Once nuclear weapons were used there would be little or no restrictions on chemical weapons (or bacteriological weapons, for that matter) in the resulting all-out struggle between the forces of capitalism and communism.

The Soviet leadership was painfully aware of U.S. superiority in nuclear potential during this period and may have considered use of chemical weapons as a substitute for atomic warheads. Besides mass effects, chemical munitions possess the advantage of limited collateral damage in certain situations. There are references in memoirs of World War II to occasions in which chemical weapons would have been useful.

In his memoirs, General Konev mentioned a European industrial region where his troops had surrounded German forces in a city. He commented that, contrary to all of his military training and instincts, he left a corridor out of the city through which the Germans were to be permitted to escape. The purpose of this act was to maintain the industrial capacity of the region intact for Soviet use following the war. Chemical weapons might have been used to achieve both desired results -- overcoming the enemy and limiting physical destruction -- simultaneously.

The theme of recovery and reconstitution following a war is common:

> According to universal recognition, a nuclear war can be a quick one. But there is also the viewpoint that after the exchange of massed nuclear stockpiles, a war will not end but enter a new stage, and can be continued with conventional weapons. [1]

Denying resources to the enemy while conserving them for eventual Soviet use seems to be a primary argument in favor of chemical warfare. Chemical weapons have advantages over nuclear weapons as well as over conventional munitions.

Concern over the psychological effects on troops and unit effectiveness when operating in contaminated conditions resulting from weapons of mass destruction led to a number of studies and experiments by Soviet military psychologists in the 1960s and 1970s. The research resulted in several books on the "psychology of the military collective". Training based on the research is intended to instill qualities increasing endurance on the battlefield under high stress conditions. Unit leader and troop selection recommendations were also based on this work.

5. Theoretical Principles

The Soviets have a half-dozen frequently cited principles of war and a number of law-governed patterns of war. Several could be applied in considerations on the tradeoffs in using chemical weapons, especially the risks involved.

The law of the dependence of the course and outcome of a war on the correlation of moral-political and psychological capabilities of the people and armies might be cited either in support or against use of chemicals, depending upon the situation. The law of the dependence of the course and outcome of a war on the correlation of forces and means might be used to argue for mass use of chemicals against an unprepared enemy to achieve a decisive change in the correlation. An enemy unprepared to meet a chemical threat could offer such a vulnerable target that chemicals would be risked in spite of the dangers of escalation. Laws concerning the dependence of the outcome of a war on national economic potential and military-economic potential might be used to argue attacking industrial regions with chemicals (see the preceding section).

Among ten law-governed patterns that Tarakanov [2] cites are the following which might be relevant to chemicals: 1) "dependence of the decisiveness and intensity of armed conflict on the moral-psychological factor;" 2) "dependence of success on the presence of superiority over the enemy in forces and means at decisive locations and moments;" and 3) "dependence of the course and outcome of armed conflict on anticipation in deployment and forestalling strike delivery." It is not difficult to envision situations in which a commander might argue any of these general principles as a basis for use of chemicals. Memoirs describing high-level deliberations on World War II mention arguments based on such principles and Russian or Soviet historical precedent.

6. Chemical Targets

Soviet doctrine and lessons learned from combat experience in other areas should ensure that chemicals will not be used initially on a tactical scale for limited objectives. Soviet writings have commented repeatedly on the failure to fully exploit surprise in a number of historical cases in which technological advantages were used for the first time. Limited use is denigrated for the warning it gives the opposition, thus preventing maximum effectiveness during later full-scale operational use.

Soviet doctrine would imply that principles of chemical use should include:

1. A strategic objective.
2. Large-scale use.
3. No prior warning and maximum exploitation of surprise.

4. Exclusion of the possibility of retaliation if possible -- for example, the capture of enemy chemical munitions or the destruction of either delivery systems or the command and control necessary for their use.

5. Preservation for Soviet use of resources currently held by the enemy while denying the enemy immediate use of the facility: airfields, ports, industrial facilities.

One possible scenario fitting these conditions would be Soviet use of chemical warfare in order to deliver the final blow in taking Western Europe. Employment of chemicals to deny NATO use of ports and airfields would be a strategic application possibly worth the potential risk. If chemical weapons could somehow be employed to deny NATO a viable nuclear response, there would be even more incentive. Soviet party-political officers, in justifying the action to Warsaw Pact troops, would blame NATO for first use.

Other types of targets likely to be considered appropriate for chemical weapons would be communications centers (in the broad use of the term), and troop concentration areas. Even without lethal consequences, the effects on an enemy in disrupting timing and slowing operations might be considered justified. Timing of operations is a primary consideration in Soviet military operational art. Chemicals might be used in combination with conventional munitions -- for example, iron bombs against airfield runways to cause craters and chemicals to obstruct repair and reconstruction.

Any use would be assessed in terms of NATO vulnerability and capabilities to operate in the resulting environment. Publicity in the United States for support of chemical programs -- pointing out vulnerabilities, deficiencies, and lack of countercapabilities -- probably increases the likelihood of Soviet use should a war occur.

Use of chemicals to gain time if the Warsaw Pact were losing is a possibility. If losing badly, however, the Soviets would be more likely to use nuclear weapons to reverse that trend, especially if NATO theater nuclear options could be restricted or denied.

Retaliation, possibly through erroneous assessment, seems another possibility. Damage to chemical storage facilities, railroad cars carrying toxic materials, chemical-processing facilities, or chemical munitions in storage could lead to the spread of gasses whose source might be misinterpreted. The fog of war could be chemically based. The Soviets' propaganda may have conditioned their troops to assess NATO first use as likely. Soviet field commanders may have authority to use chemicals in response to a perceived NATO first use.

7. Use in Local Wars

There have been several wars in which Soviet client states have apparently been given chemical-warfare support for use against unsophisticated opponents who have no comparable means of response. In Afghanistan use of chemicals seems to have been intended to terrorize rebel fighters and civilians into submission. Because of technicalities in wording, the Soviets apparently believe they are not violating treaties banning use of chemical agents (because the target countries are not signatories to the conventions).

Soviet willingness to employ chemical agents in these circumstances seems unnecessarily risky because of the propaganda implications. Whether for experimentation, for military advantage when detection is unlikely and use cannot be proven conclusively to outside parties, or for the belief that an opponent who cannot respond in kind or escalate is fair game -- the precedent set is a strong argument that the Soviets might use chemicals for reasons not clear to Western thinking.

8. Summary

Chemical weapons are probably not central factors in Soviet plans for a European campaign. They might be the optimum choice of munitions for certain targets, but the Soviets would probably prefer to do without having to operate in a chemical environment unless the advantages to them were great and the risk of unacceptable escalation very low. Lack of a NATO capability to operate in a chemical environment could present tempting opportunities, however. The same vulnerability could be interpreted as a case for nuclear use as well.

Concern that use of chemicals might accelerate NATO decisions on a nuclear first strike would be a factor against their use. If there were a strong military reason for chemicals, such reasoning might also be used to support nuclear and bacteriological use as well. If the Soviets felt use of chemicals were a necessity but also thought NATO might respond through nuclear escalation, they might prefer to preempt. The resulting risk of all-out nuclear exchange would be the major uncertainty. Rationality, in the Western view, would seem to lie in limiting escalation. I am not certain the Soviets would view it in the same way.

9. The Battlefield of the Late 1980s

An improved U.S. chemical capability providing an option to respond in kind might be a deterrent in some situations. There are other circumstances in which it might increase Soviet incentives to consider nuclear preemption. Strong, numerous conventional forces combined with a credible defensive chemical capability and a meaningful nuclear threat might be an adequate deterrent. But no option is risk free.

The Soviets see a direct conflict with the West as a probable struggle leading to the elimination of one side. If possession of chemical munitions is used as a deterrent, then the stockpile, training, and likelihood of timely retaliation must be sufficient to pose a serious counterthreat, and not be simply a token. Soviet defensive capability is very good, and a token threat will not deter Soviet use of chemicals.

Change of doctrine in the Soviet Armed Forces is slow. I do not expect battlefield conditions to change much in five years from what they might be today unless an unforeseen technological breakthrough might occur. Equipment will continue to be designed and deployed to operate in an NBC environment if possible. Research will seek new agents which could yield a technological surprise. Battlefield use of chemicals would be based on the theory which has been described. Diplomatic and propaganda efforts will be aimed at inducing the U.S. not to improve its chemical posture. Information about high-level policy on chemical use will only become available to us through clandestine sources, if at all, not through the open press. The Soviets possess options we do not, and they wish to retain any and all advantages.

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[1] Lomov, N.A. (Editor), *Scientific-Technical Progress and the Revolution in Military Affairs* (Moscow: Voyenizdat, 1973).

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Appendix C-A

Soviet Historical Experience with Chemical Warfare

During World War I Russian forces were subjected to one of the first successful uses of gas to effect a major penetration of defensive lines. German General von Hutier employed a gas attack on the Riga front on the 1st of September 1917. A heavy concentration of artillery (one gun per every eight yards for the penetration zone which was less than 4600 yards) was used to deliver a two hour barrage of gas which led to a successful breakthrough. (See, for example, Strokov (1974:463) and Rostunov (1975:v. 2, 216).

The German use of gas is similar to the type of attack one might have expected to see the Soviets themselves use in World War II had lethal chemical agents been used. The Soviets seem to have learned the lessons of World War I chemical experience and prepared for World War II with the expectation that chemicals were likely to be used.

The 1936 Provisional Field Service Regulations of the Soviet Army refer to chemical warfare primarily in terms of defensive considerations and alerting. Order No. 245 of the People's Commissariat of Defense of the USSR, signed by Marshal Voroshilov on December 30, 1936, promulgated and new regulations. Paragraph 4 of the order states, "The chemical warfare weapons referred to in the regulations will be employed only if he enemy should first resort to chemical warfare." (Ref. 3:1).

One section of the Regulations (Ref. 3:3) refers to use of chemicals to prevent enemy chemical attack:

> 64. In order to reduce the effect of hostile gas attacks, it is necessary:
>
> > a. To take all possible measures to disrupt enemy preparations for gas attacks by active measures of friendly troops (by the use of chemical shells by our own artillery, aviation, etc.)

through a comparable means of retaliation, and might also be interpreted as suggesting pre-emption.

During World War II Soviet units included Chemical Troops, and chemical munitions were stockpiled. While lethal chemical agents were not utilized, Soviet chemical troops were employed in smoke operations which were more extensively used than in other forces. Other than for employment of smoke, activities of Soviet chemical troops were apparently of little importance.

There was a Main Administration for Chemical Troops under the Commissar for Defense, similar to Main Administrations for eight other arms or technical services (e.g. artillery, tank and mechanized troops, engineers, and several others). Thus there was a high level central organization for the control of chemical supply, training, and personnel training. There was probably a General Staff Directorate for Chemical Warfare which would have been expected to develop operational policy and contingency plans.

In 1941 Soviet rifle divisions included chemical units organized into companies and platoons. Platoons consisted of an antigas squad and a decontaminating squad. Although described as antigas units, US reporting believed their primary mission was conducting refresher training and basic training for gas defense; in practice they seem to have been used primarily to facilitate assaults through use of smoke. By 1945 chemical companies were no longer included in the organization of rifle divisions.

There were also chemical troops in the Reserves of the Supreme High Command organized into companies and battalions. Flame thrower units also belonged to the Chemical Warfare Service and were organic to motorcycle battalions of tank and mechanized large units, and supporting troops of armies.

The Soviets were prepared for chemical operations and had equipment in inventory which included masks, protective clothing, projectiles, bombs, aircraft spray tanks, armored vehicles for dispensing chemicals, detection equipment, gasproof shelters for divisional staffs, and field laboratories mounted in trucks and in trains. Soviet munitions were apparently varied and numerous.

The Soviets had made relatively thorough preparations for the possibility of chemical operations in World War II. They had extensive supplies, and undoubtedly had plans for tactical employment should chemicals be used by opponents. Their extensive use of smokes provided chemical troops with some marginally transferable experience, and it meant that chemical troops were used in combat rather than awaiting a possibility that never occurred.

References for Appendix

[1] A.A. Strokov, *Vooruzhennyye Sily i Voyennoye Iskusstvo v Pervoy Mirovoy Voyne* (Moscow: Voyenizdat, 1974).

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[3] *Field Service Regulations of the Soviet Army, 1936*, typewritten translation by St.Sgt. Charles Berman, U.S.Army, September-October, 1937, Translation Section of the U.S. Army War College, Washington, D.C.

D. SOVIET CHEMICAL WARFARE DOCTRINE AND OPERATIONAL ART

YOSSEF BODANSKY
Independent Consultant

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SOVIET CHEMICAL WARFARE DOCTRINE AND OPERATIONAL ART

by

Yossef Bodansky

Since Russian troops were exposed to the first chemical attacks in 1915, the Russo-Soviet military establishment has been fascinated with the effectiveness of chemical weapons and with their operational potential. The Soviets, and the Russians, fight in the operational level where military operations are decided by the timely commitment and maneuvering of supra-units, units, and formations. Chemical weapons have appealed to the Soviets, since they can destroy complete units in a very short time with little collateral damage. These unique characteristics still appeal to the Soviets even after the introduction of nuclear weapons. The Soviet preoccupation with chemical weapons and their significance in the Soviet Art of War seems not to have been noticed by the West.

This paper deals with the issue of Soviet chemical warfare doctrine and operational art through Soviet eyes on the basis of Soviet doctrinal writings and exercises. It examines the roles and operational uses of chemical weapons as they are currently analyzed and practiced by the Soviet military establishment.

In the last 15 years the Soviets have revived and refined their emphasis on the land battlefield as the main instrument for the securing of strategic victory. They have also committed themselves to intervention and power projection in various Third World countries. Chemical weapons have central roles in all these comtemporary Soviet contingencies. Since 1978, the role of CW in the overall Soviet Art of War has been growing steadily. This paper tries to define the Soviet chemical warfare doctrine for one specific Soviet contingency -- the non-nuclear offensive in a high-intensity threat environment. This is the preferred Soviet military solution for engaging NATO in Central Europe.

The Soviets fight total wars in order to win strategic victories. The essence of Soviet victory is the collapse of the form of government of the enemy and the transformation (socialization) of its society. Militarily, the Soviets have to occupy the enemy country in order to win. When fighting against the West, the Soviets have virtually no alternative but to win strategic victory in the initial period of the war. By Soviet definition a war is decided during the initial period of the war by the operational proficiency and sophistication of the senior commanders and by the standing military forces. Once the attacked enemy succeeds in mobilizing its national-strategic potential, the war will be won by the side with the stronger economy and mobilization potential.

The Russo-Soviet Art of War has always emphasized the crucial significance of fighting throughout the entire depth of the enemy territory from the outset of hostilities. In the postwar period, in the absence of other alternatives, the Soviets considered the nuclear offensive as the substitute for operations in the deep rear of the enemy. However, since the late-1970s, the Soviets have reached the conclusion that they have the military capabilities to win strategic victory in a non-nuclear initial period of war by conducting wide-scale military operations in the rear of the enemy. Soviet doctrine and operational art, and the structure and organization of the Soviet armed forces, have undergone thorough changes in order to optimize their performance in accordance with the new strategic perception. The intensified significance of CW in the contemporary Soviet Art of War is a direct outcome of this change.

The Soviets have defined very precise, sophisticated, and demanding operational-art solutions for the conduct of a non-nuclear strategic offensive. These are based on the conduct of combined-arms and special military operations throughout the entire depth of the enemy territory. The operational-level structure of the strategic offensive is well defined: The first operational-level echelon performs a breakthrough of the enemy's first line of defense, which is saturated with anti-tank weapon systems, especially ATGMs. Once the defense line is breached, the Soviets commit various units and formations to operations in the deep rear of the enemy. These are mainly operational maneuver groups (OMG), air (airmobile) assault brigades (ShVDB), and various airborne and heliborne divisions and brigades (VDD & BON). Soon afterwards, the operational-level second echelon is committed to battle on the internal side of the defense line, and it advances as rapidly as possible into the territory of the enemy, exploiting the results of the military operations by the forces operating in the rear of the enemy to complete the occupation.

The key to the success of this strategic offensive is the securing of operational-level surprise, and timely and fast completion of all the various mission roles in every stage of the military operations. The essence of the military operational-level victory is the rapid collapse of the military system of the enemy through its inability to react to and cope with the mounting pressure from the advancing Soviet forces. Thus, the timely performance and completion of the missions within the acceptable levels of attrition is crucial to the overall success of the entire war. The Soviet forces committed to each of these missions are trained and equipped to overpower their expected opposition with their integral conventional assets. However, the Soviets are fully aware of the fact that their forces might encounter unforeseen resistance in the course of their conduct of military operations. Bound by their insistence on maintaining strict and demanding timetables, and avoiding any excessive attrition, the Soviets are determined to provide their combined-arms commanders with a "quality edge" which would enable them to determine the outcome in their favor quickly and decisively, relying only on their own assets and, despite the initial setback, within the timing and attrition requirements. Chemical weapons are this quality edge measure.

This need for chemical weapons to be the quality edge in the non-nuclear battlefield has manifested itself in the Soviet definitions of chemical weapons and chemical warfare. Until the late-1970s, the Soviets discussed the use of chemical weapons as an integral component of a nuclear war and always in connection with the use of nuclear weapons. In 1980, the Soviets discussed the use of chemical weapons in a future world war, a war which might be waged "with nuclear weapons or with conventional arms alone. The foreign military literature emphasizes that it is expedient to use chemical weapons in both cases. ...According to the experience of a number of exercises, chemical weapons were 'adopted' from the very beginning of combat operations in combination with conventional weapons." [1] Since then, the Soviets have been emphasizing the operational flexibility and combat effectiveness of chemical weapons when used under the conditions of non-nuclear combined-arms military operations.. The guiding line has been that chemical weapons can fit and be utilized with and from every weapon and delivery system, and in every level and form of non-nuclear contingency. In 1983, the Soviets were fascinated with the potential of chemical weapons which was "due not only to their high toxicity, but also to the relative ease with which they can be synthesized, their low cost, and the possibility of obtaining them in large quantities and using them in delivery means of all types, such as aerial sprays, cluster bombs, missile warheads, artillery rounds, chemical mines, etc., due to their physical and chemical properties." [2] Marshal SU N.V. Ogarkov, the main proponent of the contemporary Soviet Art of War, includes "means of armed struggle ... which are capable even in a non-nuclear war of rapidly destroying all life over enormous areas", [3] when he discusses the contemporary Soviet battlefield.

There are two choke stages in the conduct of the Soviet 'lightning' offensive: the completion of the breakthrough of the enemy first line of defense; and the conduct of offensive military operations in the deep rear of the enemy. There are built-in procedures and capabilities in the structure and assets of the combined-arms subunits and units which are to perform these missions which enable their commanders to introduce and use chemical weapons almost immediately if needed. Since the potential use of chemical weapons by the Soviets in these stages is the most likely and since they will then deliver the most significant results, this study concentrates on them.

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In order fully to understand and appreciate the magnitude of the Soviet committment to the use of chemical weapons in the course of a non-nuclear initial period of war, one should first define the organization and mission roles of Soviet Chemcial Warfare Troops (KhV) and their integration into combined-arms units and formations.

The Soviet chemical warfare troops (KhV) are 80,000-100,000 strong in peacetime. Their wartime strength is determined by the nature of the war and specific operational requirements. The commander of the KhV is Gen.Col. V.K. Pikalov. His rapid promotion since he assumed command as a Gen.Maj. in 1969 is an indication of the growing significance of the KhV in the Soviet armed forces. The KhV are defined as "Special troops designated for chemical warfare support of armed forces combat actions." 4 The Soviet description of the KhV only hints at the magnitude of their mission roles:

> "The modern Chemical Warfare Troops in the Soviet Armed Forces are comprised of units and subunits, performing missions in radioactive, chemical, non-specific biological (bacteriological) reconnaissance; performing deactivation, degasification, disinfection of armaments, clothings and other materiel-measures, as well as degasification and deactivation of the terrain. They include also subunits dedicated for the operation of flame-thrower-incendiary means and camouflage-smokes". 5

Military education, and especially officers' education, is considered by the Soviets to be of crucial significance to the establishing of high quality and effective armed forces. Thus, an examination of the educational system of the KhV can provide an indication of its overall significance and position in the Soviet armed forces. The most important institute of the KhV is The Military Academy of Chemical Defense, named for Marshal of the Soviet Union S.K. Timoshenko, and currently under the command of Gen.Lt. V.V. Myasnikov. The academy trains and prepares mid-rank officers for their future careers as senior commanders and officers. Most of the training of the students is carried out in connection with the general activities of the Soviet armed forces. The Soviets, however, emphasize the research and development activities of the faculty of the academy. Some of the leading faculty members are members of the Soviet Academy of Science. Professional officers are trained and commissioned in three higher military schools of the KhV. One of these trains engineering officers, while the other two are command schools, training and commissioning combat officers who can command subunits in general combined-arms military operations, in addition to their special training in chemical warfare matters. The Soviets, then, believe that their chemical warfare officers and commanders ought to be first combined-arms combat commanders and then CW specialists.

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4. Pikalov V.K., Chemical Warfare Troops, 'SVE', Moscow, Voenizdat, 1976-1980, Vol 8, p. 372

5. --- Chemical Warfare Troops, in Marshal SU N.V. Ogarkov (ed.) 'VES', Moscow, Voenizdat, 1983, p.794

There are nearly 1,000 training ranges dedicated to CW-related activities, some 40-50 of them with the various GSFs in Eastern Europe, and 3-5 in Afghanistan. Few of them, less than 10%, are dedicated to the training of KhV enlisted and NCO personnel. The others are KhV-operated ranges for the training of the entire Soviet armed forces. Their size and role vary from large training areas in which whole supra-units and units train in protracted large-scale combat operations under simulated conditions of nuclear and/or chemical battlefields, to localized training centers for decontamination activities, where the regular troops learn to decontaminate their combat equipment and themselves under the guidance of professional KhV personnel. The KhV also operates dedicated installations, such as a complete airbase, for the training of the troops of special combat arms to function under the conditions of chemical and/or nuclear attacks and to decontaminate their equipment and assets. Of special significance are the missile and artillery ranges where personnel of the KhV and Rocket and Artillery Troops train in the use and launching of chemical shells and warheads.

The major buildup of the contemporary Soviet chemical arsenal started in the late-1950s with the introduction of modern artillery and MBRL chemical munitions, and has grown greatly since then. Since the 1960s, the Soviets have been emphasizing operational flexibility. Currently, all the Soviet delivery systems, from small arms and grenades to artillery, MBRLs and all the missiles, are capable of delivering chemical munitions. Also, all the smoke delivery and generating systems (including the TMS-65 "decontamination" unit) as well as the integral thermic systems in all the Soviet tracked combat vehicles, have dual capabilities which enable them to deliver either toxic smoke or plain toxic agents. The Soviet Air Force has both chemical versions of its general munitions and bombs, as well as dedicated chemical munitions of various size and ranges: from 57mm unguided rockets to strategic ASCMs.

There are some 40 storage depots in Eastern Europe and European USSR which are believed to store chemical weapons. The quantities of munitions stored there constitute some 10-15% of the known comparable munitions in the same area. However, there are persistent and reliable reports that since the late-1950s Soviet chemical munitions have been stored together with the conventional systems in the operational depots of the units and formations which will use them in combat. Thus, it is impossible to distinguish between the contents of various shells, missiles and other munitions stored together. It is possible only to estimate a fraction of the chemical munitions in the known Soviet operational arsenals according to norms of fire and consumption of ammunition in applicable exercises. Current estimates stand on a third of the applicable Soviet munitions being with chemical contents, although other reliable estimates go as high as half of the munitions having chemical contents. Most of the Soviet chemical munitions contain various nerve agents.

Being special troops, the KhV are responsible for the support of the delivery of chemical weapons. The delivery itself is done either by personnel of combat arms in charge of the delivery systems or by the KhV themselves in the case of dedicated delivery systems. In the case of artillery, MBRLs, missiles, etc., the KhV personnel are in charge of maintaining and arming the chemical munitions while the KhV officers participate in the calculating of the trajectory and dissemination modes, and especially the wind effects. Helicopters delivering chemical munitions may carry KhV personnel in addition to the aircrews when needed. The KhV personnel man and operate in combat all the dedicated systems such as smoke generators and machines. KhV crews and teams also operate all the dedicated flamethrowers and incendiary weapon systems, ranging from man-carried flamethrowers to converted T-55 and T-62 tanks.

In all cases, the KhV subunits and elements are under the command of the combined-arms commander and the applicable members of his staff. Although they answer directly to the chemical warfare officer in the staff of the commander, for the operating and delivery of specific chemical munitions, the applicable KhV elements are assigned to the appropriate commander of the delivery system that will use these munitions. Thus, for example, a KhV element can be assigned to the commanders of an artillery division (=battalion) and his battery commanders for the delivery of chemical shells. When the Soviets revived the wide-scale use of chemical weapons on the battlefield, in 1960, the front and army commanders had the authority to introduce and operate chemical weapons, provided that the appropriate political authorization had been given. By the mid-1970s, following the reorganization of the ground forces into real combined-arms units and formations, the authority was transferred to division commanders. One of the major lessons and impacts of the Soviet military operations in the eastern provinces of Afghanistan has been the reorganization of the combined-arms subunits and units, and the unprecedented authority and operational flexibility given to their commanders. Currently, the authority to use chemical weapons is given to the combined-arms regiment commander. The regimental staff include professional fire support, artillery, aviation (helicopter), and chemical officers, so that the regiment commander can conduct complete operational-level combined-arms combat operations , including the use of chemical weapons, providing the political authorization has been given. This change in the command authority is of crucial significance for the ability of the Soviet units and subunits involved in the combat operations, and especially in the two choke stages, to react in time to unexpected crises and introduce their quality edge means. The Soviets are fully aware of the fact that the fate of the entire war might hinge on the timely completion of some of these choke combat operations.

Breakthrough operations have always been considered both extremely complicated and crucial in Soviet Operational Art. The introduction of sophisticated anti-tank weapons, and especially ATGMs, has made breakthrough operations even more challenging.

"An analysis of the offensive operations shows that for successfully breaking through an enemy defense it is essential not only to reliably neutralize the defense but also to carry out the offensive at a rapid pace so that the enemy is unable to regroup its troops and organize a defense in depth; the breakthrough must be broadened towards the flanks; the enemy reserves must be prevented from reaching the breakthrough sectors; there must be dependable cover for the troops, particularly the main forces, against air strikes. Under present-day conditions, in an offensive employing conventional weapons, for a breakthrough it may also be necessary to involve large masses of artillery, aviation and tanks, to ensure the reliable neutralization of numerous antitank weapons and provide air cover including against strikes by gunships. For increasing the momentum of advance and preventing the approach of enemy reserves to the breakthrough area it is essential to make missile and air strikes over the entire depth of the area as well as widely employ desants. The experience of employing desants ... showed the need for making the landing quickly in order not to lose the surprise factor, the enemy should be neutralized in the landing area and near it while reconnaissance must establish precisely the enemy resources in the landing area."[6]

The Soviets believe in determining the outcome of strategic military operations while fighting throughout the depth of the enemy territory from the earliest possible stage of the hostilities. Protracted assault on the enemy anti-tank defense could develop into lengthy and costly exchanges that might end up successfully, but too late to attain a strategic victory in the initial period of war. Breakthrough operations are considered means to enable the Soviet forces to penetrate deeply into the enemy rear, and not a goal in their own right. Thus, it is a Soviet interest to commit as few forces as possible to the conduct of the breakthrough operations.

The Soviets solve this problem by overwhelming the defenses with collateral fire suppression which should enable the main forces to move through the defense dispositions without having to engage in direct combat. The Soviets do not intend to occupy the defense lines until a late stage of the war. The mission role of the forces committed to the breakthrough operations is to establish safe corridors through the defense lines for the main forces to pass through and develop the offensive to the rear of the enemy. At this stage, the enemy forces ought to be neutralized and unable to offer meaningful resistance to the advancing forces.

In 1976, in the heat of what became the "BMP debate" that defined the techno-tactical and operational-art procedures of the contemporary Soviet combined-arms battlefield, the Soviets decided categorically that "When attacking using conventional weapon systems, the motorized-rifle subunits normally attack the enemy on foot."[7] In 1981, during the milestone

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6. Gayvoronskiy, Gen. Col. F., Development of Operational Art, 'Voyenno Istoricheskiy Zhurnal,' No. 12, December 1981.

7. Merimskiy, Col. Gen. V.A., The BMP in Combat, "Voyenniy Vestnik,' No. 3, March 1976

'ZAPAD-81' exercise, in which the entire Soviet concept of winning strategic victory in a non-nuclear initial period of war was tested and verified, the Soviets diverged from the normal procedure. During the major breakthrough operation (September 9, 1981), the leading reinforced battalion of the leading regiment of the 120th Gds. MRD fought throughout the enemy defenses with the troops mounted on and fighting from their BMPs. The battalion performed the breakthrough by moving rapidly through the enemy positions, with all weapon systems delivering massive direct laying fire which overwhelmed the enemy and suppressed its fire. The battalion used mainly T-72s, BMPs and 2S1 SPGs. The battalion cut through the enemy first line of defense, establishing a wedge through which the friendly forces could move. It took the Soviets some 30 minutes to break through the 15-20 mile deep enemy defense lines, which were saturated with ATGMs, and another 10 minutes to consolidate their gains and commit to battle the OMG.[8] This breakthrough operation has been presented by the Soviets as a prototype of the contemporary approach to the conduct of breakthrough operations. They have emphasized the fact that the troops fought from their combat vehicles. In such a case, these troops could have enjoyed the centralized protective system of all the Soviet combat vehicles.

The Soviets are fully aware of the effects that toxic agents (OV) can have on fortified defenses. They consider the chemical attacks, or their mere potential, to be the greatest threat to anti-tank defense short of a nuclear attack: "OV are quite toxic, and manpower can be taken out of action within a few minutes after a chemical attack. During the fire attacks of artillery and strikes by aviation, it is impossible to determine at what moment the enemy used chemical munitions. In the noise of combat, it is doubtful if it is possible to distinguish between the explosions of conventional and chemical munitions. It is practically impossible to discover modern OV under extreme conditions. But if the moment of alert is missed, the manpower is exposed to large doses."[9] The Soviets claim that the only solution to such a threat is for the defending troops to operate in full personal protective gear, with all the ramifications for loss of fighting ability and extreme inconvenience. The alternative is for troops to be caught unaware in a surprise introduction of toxic chemicals in the middle of a breakthrough operation involving suppression by fire. The attrition among the defending forces would then be unbearable for any army, and would result in the collapse of the entire defense line.

A close examination of Soviet smoke operations in the course of breakthrough operations clearly indicates that the Soviets have acquired the techno-tactical capabilities to do just that. Their smoke-related exercises and equipment have the built-in option to escalate and introduce toxic agents by surprise. Smoke-screen laying is the responsibility of the KhV, while the thermal smoke-generating systems in the exhausts of all Soviet tracked combat vehicles can also disseminate toxic-smoke, mustard, and nerve agents within seconds after the conversion. During breakthrough operations the Soviets intend to shield their troops from enemy ATGMs, which need visual guidance in the West, by laying camouflage and dazzling smoke-screens.

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8. Ivaschenko, Gds. Maj. V., Attack on Infantry Fighting Vehicles, 'Voyenniy Vestnik,' No. 7, July 1982

9. Moskalev, Col. A., Protection of Subunits in Defense, 'Voyenniy Vestnik,' No. 9, September 1971

"A smoke-screen is dazzling when the smoke disseminates directly into the dispositions of the enemy, covers his ground observation points and fire positions. In such cases, the enemy cannot conduct observation of the battlefield and aim his fire. Our subunits, however, operate outside the zone of smoke-screen and have complete freedom of maneuver. Such screens are created by artillery, mortar and aviation smoke munitions in all wind directions, and by smoke generators and machines, and pots only when the wind blows into the face of the enemy."[10]

The current Soviet emphasis on conducting breakthrough operations while mounted, and thus protected without having to don personal protective gear, is intended to give Soviet forces complete freedom of operation and keep them out of danger if the wind shifts the "smoke" in their direction. The Soviets would do their utmost, in the course of breakthrough operations, to suppress the enemy's fire and overwhelm its forces, using only conventional weapons. However, it is far more crucial for them to make sure that their commanders complete the breakthrough operations within the highly demanding timetables, relying only on their own assets, and within the permissible level of attrition. Their commanders have the authority and capability to introduce the quality edge -- chemical weapons -- by surprise, and in reaction to a local crisis, and secure victory.

Once the breakthrough has been completed, the Soviets commit a wide variety of supra-units, units, and subunits for extensive military operations in the deep rear of the enemy. Their goal is to exploit tactical success and turn it into operational-level success. If these military operations are conducted quickly and deeply enough, they can cause the collapse of the enemy's capabilities to wage war, and thus deliver strategic results.

The nature of such military operations calls for relatively small formations which have to operate in the deep rear of the enemy, isolated from the main friendly forces. Although these formations enjoy far superior operational flexibility and fire power when compared to regular formations of similar size, they are usually inferior in size and fire power to the forces they have to engage while in the rear of the enemy. The survival, let alone effectiveness, of these forces depends on their ability to seize and maintain the initiative by being able to concentrate all their assets against the enemy, while denying it access to their flanks and rear.

"In the offensive operations of the Great Patriotic War, the tank and mechanized corps were ordinarily employed for exploiting success as mobile groups of the combined-arms armies and fronts. Their technical support was significantly influenced by such factors as the high rates of advance and their great separation from the combined-

10. Afanasov, Gen. Maj. I., Under the Cover of Smoke-Screen, 'Voyenniy Vestnik,' No. 8, August 1972

arms formations. The corps frequently had to conduct combat operations with greatly overextended and in a number of instances unsecured lines of communications, under the conditions of an increased threat of enemy attack both from the flanks and from the rear. Their situation was also complicated by the fact that ... it was essential also to ensure autonomy (combat independence) of the tank units and formations in operations in the operational-level depth."[11]

The growing rates of combat operations, and the fire power that units and formations can generate, have complicated the missions of the OMGs and the other Soviet formations operating in the rear of the enemy. The main challenge is the securing of enough fire power to enable the OMG to overpower any enemy engaged in a brief decisive meeting encounter, while operating without danger to its exposed flanks and rear.

"It is not difficult to see that the rate of actions will grow to the degree that the artillery means of fire on the ground will not be able to support with fire the attacking units in the air-land dimension. Thus for some time now, fire support is organized in armies in certain situations using assault helicopters. Except for that, special elements of combat organizations like dedicated air power against armor, blocking air power, and supporting fire power of helicopters clearly show that the actions of the ground forces ought to be examined in the air-land dimension."[12]

The Soviets must have some solutions to the seeming contradiction between the growing threat to the OMGs and other forces operating in the deep rear of the enemy and their growing numbers and the intensifying significance of their mission roles. The Soviets emphasize that a key contribution element to the survival of the OMGs is their constant, steadfast, and uninterrupted movement. However, while operating in the deep rear of the enemy, Soviet units might have to engage and storm-cross areas of chemical contamination. While the Soviets ignore the issue of which side delivered the chemical attack on the rear of the enemy, they warn their troops on the effects of such attacks. They indicate even further, that a direct result of the conduct of deep penetrating offensive operations is the enemy's inability to use weapons of mass destruction for fear of friendly losses:

"During the steadfast and uninterrupted actions, the subunits rapidly penetrate into the depth of the defense of the enemy, break up his combat deployment and capture and destroy his weapons of mass destruction. This makes it possible to maintain direct contact with the enemy, wage active combat in zones of destruction and contamination and rapidly leave areas of possible strikes and those with high levels of radiation.

"If the front line cannot be clearly distinguished, and the attacking forces are rapidly advancing along parallel axes of advance, the enemy will not be able to strike them with nuclear weapons due to the fear of hitting his own retreating forces.

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11. Krupchenko, Maj. Eng. A., Technical Support of Tank and Mechanized Corps Operating as Mobile Groups, 'Voyenno Istoricheskiy Zhurnal,' No. 6, June 1982

12. Szykowski, Col. J., Unity of Maneuver and Fire, 'Zotnierz Wolnosci,' (Poland), n.d. in 1980

Under these conditions, he will have difficulty in setting up and preparing for use nuclear or chemical weapons. Given that even in the second and rear echelons the positions of the subunits are constantly changing, intelligence information about them will be rapidly outdated. This also reduces the threat or effectiveness of nuclear and chemical strikes.

"Consequently, if in contemporary battle troops are attacking steadfastly and continuously, day and night, this contributes to the safety of the manpower and to the protection of the subunits against weapons of mass destruction. One can anticipate that in this case their losses due to weapons of mass destruction, as well as to conventional weapons, will be significantly fewer. The great mobility of the subunits and the dispersal of march and combat formations -- together with superiority of fire over the enemy, readiness to execute preemptive maneuvers and actions in separate directions -- create favourable conditions for the preservation of their combat capability and the accomplishment of their missions."[13]

The Soviet forces operating in the deep rear of the enemy ought to perform missions of strategic significance. These include the capture or destruction of objectives such as nuclear weapons (storage and delivery positions), C3I centers, airbases, a variety of air-defense-related installations, as well as the capture and holding of critical choke points, denying them to the enemy and holding them until the main friendly forces arrive. At the same time, they have to move constantly, engaging and overpowering superior enemy forces. Recently, Soviet forces have been reorganized in order to optimize their performance when operating in the deep rear of the enemy. "Motorized-rifle and tank divisions of the ground forces now have hundreds of modern tanks, infantry fighting vehicles, and armoured personnel carriers, and a sufficient quantity of self-propelled artillery and combat helicopters. They have the potential to conduct combat operations independently at a high pace and to rapidly exploit success in depth."[14] The Soviets consider the exposed flanks and rear of these forces as their chief vulnerability,since a commander cannot conduct initiated bold offensive operations and at the same time worry about, and allocate troops and assets for, protective purposes.

In many cases, especially airborne and heliborne desants, forces must capture or destroy strategic objectives in the deep rear of the enemy which are fortified and protected by superior forces. The airborne and airmobile units and fortifications are uniquely equipped with a delivery system optimized for the dissemination of chemical munitions. It is the RPU-14 multi-barrel reactive system, which is a version of a

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13. Kudachkin, Col. Yu. & Polyak, Col. A., Steadfast Actions and Protection of Troops, 'Voyenniy Vestnik,' No. 5, May 1983

14. Ogarkov, op. cit.

MBRL. "Multi-barrel reactive systems are favourably different from regular artillery for the delivery of chemical ammunition. With their help, it is possible to deliver within a short time a massive sudden strike on a relatively large area."[15] The RPU-14 is a 16-barrel, 140mm MBRL, with an effective range of 6.65 miles. Its crew can reload it in less than 4 minutes. Each artillery battalion of an airborne or airmobile division or brigade has a 'divizion' of 18 (or even 24) RPU-14s. It is highly mobile and airdroppable. The RPU-14s are designed to create protective screens for assault troops operating in the enemy rear, and to enable them to deliver a surprise chemical attack on major installations they are to capture or destroy, or to protect themselves against superior enemy forces. In almost all the exercises in which the RPU-14 has been used, the VDV crews, operating in the deep rear of the enemy, have been wearing personal protective gear while launching barrages of RPU-14 rockets.

The Soviets provide their commanders operating in the rear of the enemy with unprecedented operational flexibility and autonomy: This includes the ability to use chemical weapons. Soviet OMGs will protect their flanks and rear, especially when they are organizing for and conducting meeting encounters, by laying protective screens of persistent nerve agents. In such a case, the enemy will not be able to launch a surprise attack on the flanks of, or outmaneuver, the OMG. In its struggle to seize the initiative, the commander of the OMG can deny the enemy access to a certain area by creating contaminated blocks along certain axes. When on the attack against superior enemy forces, the OMG can introduce the quality edge -- chemical weapons -- if threatened. The Soviets write routinely of exercises in which similar problems are solved through the use of dazzling smoke. "Artillery and mortar smoke projectiles form a cloud of white smoke at the burst location in 1-3 seconds ... Smoke screens can be made suddenly inside the enemy's combat formations using artillery and mortar smoke projectiles."[16] Soviet units and subunits are organized and equipped to be able to escalate to the use of chemical weapons, should the need arise, on a local discrete basis. The Soviets will do so if it is the alternative to failing to complete the mission. The repeated exercises in which Soviet subunits encounter contaminated zones in the deep rear of the enemy following combat operations in which the enemy has been denied the ability to use chemical weapons are a clear indication of the Soviet perception of the conditions their forces will encounter in the deep rear of the enemy. The diversified exercises in which Soviet subunits operating under similar conditions use dazzling "smoke," point to the modes of delivery.

The Soviet armed forces are equipped, organized, and trained to operate under what the Soviets believe to be optimal conditions, in all contingencies, including that of having to use chemical weapons and operate under conditions

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15. Manets, F.I. et al., 'Protection Against Weapons of Mass Destruction,' Moscow, Voenizdat, 1971, p. 37.

16. Varenishev, B.V., et al., 'Military-Engineering Training,' Moscow, Voenizdat, 1982, p. 142.

of chemical contamination. Their personal protective gear is optimized for preplanned and very brief wearing. Soviet combat vehicles have centralized protection systems that enable the troops inside to storm-cross contaminated areas without having to don personal protective gear. Thus, Soviet chemical warfare doctrine, as well as Soviet protective gear, are optimized for Soviet-initiated offensive use of chemical weapons.

The contemporary Soviet Art of War creates opportunities where the surprise introduction of chemical weapons can change the outcome of strategically significant battles and combat operations. The Soviet arsenal of chemical weapons applicable for surprise introduction in the contingencies described here includes both lethal and non-lethal agents. The wide Soviet experience in Afghanistan in using various knock-out agents based on concentrated forms of CS, and especially the "Blue-X," clearly demonstrates the huge potential of this weapon. In the short run, its effects are comparable to those of lethal agents. It neutralizes the enemy completely. On the other hand, the West has no comparable weapon system, and it cannot retaliate in kind. The Soviets believe that the West will not introduce lethal chemical weapons unilaterally. Thus, in breakthrough operations where the operational requirement is for brief complete neutralization of the enemy until the forces have passed through the wedge-corridor, knock-out agents can be the ideal weapon. The newly introduced Czechoslovakian-made chemical "capsule" (a 2.64"-long, 0.28"-diameter mini-grenade which emits gas for 6-8 minutes), as a personal weapon, even if "only" with CS, is a major step in the complete integration of chemical weapons into the non-nuclear battlefield.

Chemical warfare is fully integrated into the Soviet military system. It is an integral component of the Soviet combined-arms battlefield. The Soviet regiment commander is authorized to employ and deliver chemical weapons. His assets include a wide variety of weapon systems which can deliver chemical munitions, and professional KhV subunits are assigned to him. The degree of integration of chemical weapons becomes clear when one considers the fact that the regiment commander does not control either combat aircraft or SAMs (except for immediate protection), and that a call for an air strike of fighter-bombers on behalf of his regiment, or a call for deployment of medium-range SAMs for his regiment's protection, is a far more complex and lengthy process than the offensive employment of chemical weapons.

Soviet citizens are aware of chemical weapons from cradle to grave: An infant in a day-care center learns to remain in a protective cradle, high school "initial military studies" include functioning on a contaminated battlefield, workers routinely exercise the decontamination and operation of their factories under conditions of chemical contamination, wearing complete personal protective gear, while the elderly participate in chemical watches in their neighborhoods. In the military, the Soviet soldier is engulfed with awareness of weapons of mass destruction, with a growing emphasis on chemical warfare. The first thing a Soviet soldier is issued after registration for active service -- draftees and reservists alike -- is personal protective gear. Routine training in proficiency in using it is conducted every 2-3 days. The current emphasis is on donning it under conditions of pre-warning of an expected contamination. For the Soviet soldier, functioning in personal protective gear is very tiring and unpleasant. But it is also an integral part of his daily routine military environment. He may not like it, but he will not be surprised if ordered to don his protective gear in combat. For the average Soviet soldier, there is nothing special in the existence of contamination on the battlefield, and it is all too obvious to him that he will have to continue to operate regardless of these conditions. For him, there is nothing special or irregular in the commander's decision to go chemical if he sees fit.

The Soviets are committed to the winning of strategic victory in a non-nuclear initial period of war. The key operational-level military operations which might decide the outcome of the war have a built-in option to escalate to use of chemical weapons by the local commanders in reaction to local crises. The Soviets do not want an all-out chemical war since it might compel them to operate in protective gear, and might even expose them to surprise attacks by the enemy. The possibility of retaliation worries them, despite their impressive chemical defense capabilities. Discussing why the Great Patriotic War did not escalate to a chemical war, they explain that the Germans did not use their chemical offensive capabilities because they "could not fail to consider the high state of readiness of the Soviet Army for defense against these weapons. Fear of inevitable retribution also restrained it [Germany]."[17] The Soviets use the term 'restrain' in the context of balance and correlation of forces. (It is their version of the US active deterrence.) The Soviets emphasize here that regardless of the quality and efficiency of chemical defensive measures, the general strategic decision to introduce chemical weapons depends mainly on the ability of the enemy to retaliate in kind, let alone make a surprise first use.

Soviet Operational Art is optimized for Soviet surprise unilateral introduction and use of chemical weapons. The Soviet command structure is organized to allow the local commander to use chemical weapons in order to determine the outcome of local problems. The cumulative Soviet experience from the routine use of chemical weapons in Afghanistan has proven that their use by regiment and battalion commanders in small-unit operations is not only possible but highly effective. The Soviets are not likely to ignore such valuable experience. They emphasize that "although the opportunities for practice in peacetime conditions have greatly improved, this is still no substitute for practice in wartime."[18]

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17. Zemzerov, Gen. Lt. V., Loyalty to Traditions, 'Krasnaya Zvezda,' 15 May 1982

18. Chuyev, Yu. V. and Mikhaylov, Yu. B., 'Forecasting in Military Affairs,' Moscow, Voenizdat, 1975; Eng. Ed. USAF's Soviet Military Thought Series, vol. 16, p. 60

The lessons of Afghanistan should be regarded as an indication as to the essence of the control-management of chemical weapons in the Soviet Art of War: An integral component of the non-nuclear small-unit military operations, under the complete authority of their combined-arms commanders.

The Soviets will use chemical weapons in a future non-nuclear war in a discrete manner, for the localized solution of problems. They will be introduced by the local combined-arms commander as a routine measure. When placed in the perspective of a collapse and loss of Western Europe, such a discrete use of chemical weapons is not going to cause any change in the Western decision to escalate unilaterally to the use of nuclear weapons. On the other hand, the discrete use of chemical weapons can determine the Soviet ability to win the strategic victory in the non-nuclear initial period of war. The Soviets are committed to winning that war. Thus, chemical weapons, as an integral component of the Soviet non-nuclear combined-arms force structure, are on the Soviet battlefield to stay.

E. CBW: A TECHNICAL VIEW

MICHAEL A. WARTELL
James Madison University
Harrisonburg, Virginia

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CBW: A Technical View

Michael A. Wartell

James Madison University

Introduction

The use of chemical and biological agents as weapons in conflict situations is reasonably well documented, from the first use of poisons by the ancients, through the use of smokes to gain tactical advantage, to the modern era in which lethal chemicals have been weaponized as means for widespread destruction. In spite of worldwide public abhorrence of the use of chemical agents on the modern battlefield as supported by the existence of several international treaties banning their use, an increasingly public debate concerning the development of new chemical/biological weaponry by the United States military has begun. The debate has been fueled partly by the suspected use of such agents by the Soviet Union in Afghanistan and by Soviet surrogates in Southeast Asia, and partly by reports indicating extensive chemical/biological agent production facility and research effort within the Soviet Union and intensified chemical/biological warfare preparedness within the Soviet military.

Whether one agrees or not with either side of the debate concerning the use of chemical/biological weaponry, or concerning the level of intensity of the chemical/biological threat posed by the Soviet Union, or concerning the intention of the Soviet military and political planners with respect to use of chemical/biological weaponry, one must realize the immense difficulties which would confront U.S. forces if those forces were caught unprepared in the event of a chemical/biological attack. Preparedness includes some combination of protection of one's own forces and appropriate deterrent capabilities. Thus, in recent years, the United States' policy has included investing in the technology necessary to develop credible capabilities in detection, protection, and decontamination, maintenance of a chemical weaponry stockpile as a deterrent, renunciation of "first-use" of chemical weaponry, and maintenance of no biological warfare capability.

Unfortunately, the enunciation of this policy occurred after a ten-year period of neglect of the chemical/biological warfare research and development effort. Additionally, during this time, much of the "corporate knowledge" and institutional commitment to any concerted research and development program disappeared. Therefore, when it appeared that the Soviet Union had not only continued to attend to development of chemical warfare capabilities throughout the decade from 1969-1978, but had also supported technical advances with significant increases in the force structure supporting chemical/biological warfare, the United States research and development community was compelled to respond quickly to increased pressure for defensive capabilities. That response is only now, after five years, beginning to make headway.

Adding to the personnel protection problem is the fact that what deterrent potential exists in the U.S. chemical stockpile is aged and may be deteriorating (U.S. chemical weaponry is, literally, "stockpiled"). However, that aspect of the chemical/biological policy problem will be ignored in this paper.

This paper will examine, however, technical and some tactical vulnerabilities by assuming the point of view of an unfriendly military planner. It will first examine some properties and tactical usefulness of chemical/biological agents, the defensive capabilities in the chemical/biological arena of the U.S. military, and the credibility of the chemical/biological offensive stockpile as an effective array of weapons. It will then examine the system by proposing research and development initiatives which will insure defeat of that system, assuming such an intention on behalf of Soviet planners.

Chemical/Biological Agent Stocks and Delivery Systems

There exists, in the commonly accepted lexicon of chemical weaponry, a set of known and allegedly widely stockpiled chemical agents. They can be categorized according to several schemes, including one based on physiological effects, one based on persistence in the environment, and one based on chemical structure. A short compendium of common agents is shown in Table 1 along with some general properties.

It is worth noting that while blood agents pose only an inhalation hazard; nerve and blister agents pose a percutaneous hazard as well.

Since the United States has been, essentially, "out of the business" of chemical/biological offensive weaponry production since 1969 when the Nixon administration decided to abandon all stockpiles of biological

Table 1

Selected Chemical Warfare Agents and Properties

	Chemical Formula	Other Names	Persistent[1]	Non Persistent[2]	Physiological Effect
Hydrogen Cyanide	HCN	AC		X	Blood Agent
Phosgene	$COCl_2$	CG		X	Choking Agent
Mustard	$(Cl\ CH_2CH_2)_2S$	HD	T[3]		Blister Agent
Lewisite	$(Cl\ CH\ CH)_2AsCl$	L		X	Blister Agent
Sarin	$(CH_3)_2CHO(CH_3)FPO$	GB		X	Nerve Agent
Soman	$(CH_3)_3CCH(CH_3)OPF(O)CH_3$	GD	T[3]		Nerve Agent
VX	$(CH(CH_3)_2)_2N(CH_2)_2S\ P(O)(OC_2H_5)CH_3$		X		Nerve Agent

1 Effective lifetime measured in days (25°C, calm, dry)
2 Effective lifetime measured in minutes or hours (25°C, calm, dry)
3 Thickeners added.

weaponry, freeze all chemical weaponry stockpiles, and desist in offensive weaponry research and development, it can be assumed that the U.S. stockpile contains no more agents (other than non-lethal varieties, tear gas, etc.) than those listed in Table 1. It is alleged, and rather widely accepted, that the Soviet Union's stockpile of chemical agents is similar, including stocks of hydrogen cyanide, phosgene, mustard, soman, and some V-type agent. However, this must be assumed to be a minimum estimate of Soviet weapon stockpiles. Thus, if one accepts the evidence gathered in Southeast Asia and Afghanistan concerning use of toxins and new incapacitating and lethal agents, one must believe that the Soviet research and development effort has led to development of agents other than the ones listed in Table 1.

With respect to biological weaponry, the United States holds no stockpiles. The "1969 standdown" included destruction of all biological stocks. The Soviet Union, on the other hand, seems to be continuing to experiment with biological weapons, as supported by the interpretations of the Sverdlovsk pulmonary anthrax accident and other incidents. One can only assume that development of such agents continues.

The assumptions drawn from the foregoing discussion for use in later sections include

a) A static (possibly deteriorating) U.S. stockpile of chemical warfare agents exists.

b) A Soviet stockpile of chemical warfare agents similar to that held by the U.S., but augmented by new agents developed since 1969 is probable.

c) No extant U.S. stockpile of biological warfare agents exists.

d) An extant but unknown Soviet stockpile of biological warfare agents exists.

Delivery systems will not be discussed, except to say that it will be assumed that the Soviet Union possesses the capability to launch chemical strikes using artillery for short range strikes, multiple rocket launchers for medium range strikes, and FROG and SCUD missles for deep strikes. Bombs, mines, and spray tanks are also presumed to be available. The United States possesses chemical artillery shells, mines, and bombs, and some spray tanks.

Detection, Protection, and Decontamination

Historically, chemical weapons have been most effective when used against unprotected personnel. Therefore, in order to minimize the effects of use of chemical/biological weapons, both the Soviet Union and the United States have developed systems which adopt a three-pronged approach to personnel protection. First from the aspect of direct protection of the individual soldier, a protective ensemble which includes mask, gloves, boots, and an overgarment has been developed. Since wearing the ensemble is detrimental to warfighting capabilities, limiting time spent wearing it to only those times when there is a real chemical challenge is appropriate. Therefore, detection systems have been developed as the second aspect of the approach, in order to provide timely warning for donning the ensemble when a challenge exists and for doffing the ensemble when the challenge evaporates or one moves out of a contaminated area. Detection capabilities also allow one to avoid contamination. The third aspect of the approach, decontamination, is aimed at eliminating danger to personnel posed by equipment and personnel which have been contaminated with a persistent agent, allowing them to doff protective gear at the earliest possible moment. The philosophy supporting the overall approach is sound and logical, but the execution of the concepts leaves critical vulnerabilities which will be discussed later in the paper. In order to discuss those vulnerabilities, however, it is appropriate to discuss several more detailed aspects of the U.S. approach.

Detection

Detection of chemical agents is necessary in order to provide information to combatants concerning when chemical attack is occurring and which terrain, equipment, and personnel are contaminated. Detection systems can be divided into two general categories, remote detectors and point (or site) detectors. For remote detection, technologies which are not being explored include infrared sensing, opta-acoustic sensing, and others. Point detection is further along. The contamination agent monitor (CAM) unit exists now and is in early production. It was developed in concert with the Chemical Research and Development Center at Aberdeen Proving Ground and uses the principle of ion mobility spectrometry to identify known persistent agents (principally mustard and nerve). The United States also has an automatic chemical agent detection and alarm system, based on roughly the same technology, which will be fielded in 1988. The new U.S. system is more versatile than the CAM, but is also more bulky. Other point detection systems are being developed, one of the most promising of which is a mass spectrometer-based system.

Detection systems for biological agents are in the earliest stages of development.

Little is known about the Soviet detection capabilities. However, given the dearth of change in agent types in the U.S. arsenal over the last fifteen years, the problem of developing detection systems effective for U.S. agents is a limited one for the Soviets.

The assumptions drawn from the foregoing discussion for later use include:

a) The U.S. forces are continuing to develop capability for remote detection of chemical agents.

b) The U.S. forces will have an improved point detection capability for some known chemical agents in the near term.

c) The chemical agent detection problem is a bounded one for the Soviet Union since the U.S. chemical arsenal remains unchanged.

d) No biological agent detection capability is necessary for the Soviet Union except as applied to Soviet generated threats.

Protection

The need for protecting personnel (both individually and collectively) against chemical agents has been accepted for many years. However, the level of individual protection necessary and the concomitant performance degradation has not.

Since many chemical agents pose a percutaneous as well as an inhalation hazard, it is necessary to cover all exposed body surfaces with appropriate protective garments and provide a mask as well. The U.S. has fielded a mask which depends on a combination of a particulate filter and an absorbent charcoal filter* for effectiveness. For protective uniforms, the

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*It is important to note that charcoal filters have finite effective lifetimes depending on the concentration of agent in the atmosphere. The determining factor for this lifetime is the availability of absorbing sites on the charcoal for agent absorption. Once agent adheres to a site, the site is effectively inactivated.

U.S. has aimed at minimizing heat stress, developing a charcoal impregnated, permeable uniform supplemented with impermeable gloves and boots. Heat stress remains a problem, however, and U.S. forces' battlefield effectiveness will be lessened while wearing the entire protective ensemble. Therefore, doctrinally, the attempt is made to minimize time spent in the ensemble by avoiding chemical contamination where possible and decontaminating when appropriate.

The U.S. ensemble will probably be effective against biological agents, also, except under special circumstances.

The Soviet Union has chosen to protect its forces using a similar masking system, but less permeable overgarment, including an impermeable cape. However, one would assume that the Soviets are developing the next generation of protective ensemble.

Collective protection devices are also beginning to be fielded based on the same charcoal and particulate filter technology used in the mask. These include vehicle interior protection, truck mounted clean areas, and temporary shelters.

Assumptions drawn from the previous discussion to be used later in the paper include:

a) The U.S. chemical agent protective ensemble, while causing degradation of general performance in battle-field situations, protects the individual soldier adequately against known Soviet chemical threats and assumed biological threats.

b) The Soviet chemical agent protective ensemble protects the soldier against all threats extant in the U.S. arsenal.

Decontamination

Decontamination of personnel and equipment exposed to persistent chemical agents has consistently been a part of the U.S. research and development effort. The U.S. military is prepared to use chlorine-based oxidizing solutions in a "mop and broom" effort to decontaminate equipment. Such an approach is logistically difficult and exposes units to great battlefield risk. Also, the necessary doctrine and force structure to an effective overall effort has not been well developed. Finally, the methods employed are certain to be effective only with known chemical agents. While new technology, doctrine, and force structure are planned, those new initiatives have not yet been completed.

The Soviet Union has expended a great deal of effort and developed force structure appropriate to dealing with decontamination on a large scale using both liquid decontaminants and forced, heated air. Their methods will effectively decontaminate all agents in the U.S. arsenal.

The assumptions drawn from the previous section for use in later discussion include

a) The U.S. decontamination capability is such that known persistent agents will succumb to the approach but other, previously unknown agents may not.

b) Soviet decontamination methods will be effective against all agents in the U.S. stockpile.

Tactical/Strategic Usefulness of Chemical/Biological Weapons

The effectiveness of chemical/biological weapons depends on the degree of protection enjoyed by target personnel. For obvious example, if a unit has been vaccinated against smallpox, it makes little sense to expose them to some weaponized smallpox threat. Similarly, the U.S. soldier, properly attired in a chemical warfare protective ensemble, enjoys nearly complete protection against exposure to the chemical agents listed in Table 1 and most biological agents. In what situations and under what conditions then, is the use of chemical/biological weaponry useful?

In general, chemical/biological weaponry containing agents known to exist in stockpiles will have maximum significance under the following circumstances:

a) When surprise is achieved to the extent that timely donning of the protective ensemble cannot be achieved.

b) When causing opposing forces to don the protective ensemble will significantly lessen their effectiveness.

and under the following conditions:

a) When weather and terrain conditions are such that effects of chemical weapons are not rapidly mitigated.

b) When chemical/biological weapons are chosen appropriately to achieve the maximum effect. In general, one chooses to use nonpersistent agents to cause casualties, and/or buttoning-up in areas where one wishes to insert one's own troops. Persistent agents are used in order to deny terrain to enemy forces and/or to create long-term contamination and protection problems for opposing troops. Biological are, in general, slow acting and will probably be most effective as pre-war "softening-up" agents and in protracted engagements. Thus, one might expect that biologicals will be surreptitiously introduced. Toxins might be used either in battlefield situations or in sabotage operations.

The Future Chemical/Biological Encounter

Given the set of assumptions presented in the foregoing discussion, and given the ability to direct a research and development program toward defeat of the United States chemical/biological defensive posture, how might hostile military planners direct their efforts?

a) Defeating detection. Fielded detection systems depend for success on identifying physical characteristics of known molecules or parts of those molecules. Therefore, unless the hazard entity is previously known and the detector system "tuned" to it, it will escape detection. In order to defeat detection systems, one would aim a research effort at developing chemical agents which would not trigger alarms, i.e. non-phosphorus based nerve agents, quick acting toxins, etc. Alternatively, one could attempt to develop chemical agents which were harmless, but caused the alarms to react. One's own forces could then fight unencumbered by protective ensembles, while enemy forces were degraded by being forced into protective posture. After some period of time by which enemy forces down-dressed thinking that all alarms were false, one could employ lethal chemicals on previously protected, but now unprotected troops.

b) Defeating protection. The protective ensemble's effectiveness is based on the ability of charcoal to absorb chemical agents. Several possible defeat mechanisms exist. One approach might be to overwhelm the charcoal with so much agent that all receptor sites are taken. Another is to develop an agent (either lethal or irritating) which passes through the filter. The wearer either succumbs to lethal agent passing through the filter or removes the mask to ease the effect of an irritating agent, causing exposure to lethal agent which has been used in tandem with the irritant. Still another approach to mask and/or suit degradation would be to develop chemicals which "poisoned" charcoal. Such chemicals would preferentially adhere to absorption sites where chemical warfare agents were usually trapped, thereby allowing lethal agents to pass through the mask or protective garment. These degrading chemicals could be applied in tandem with lethal agents if they were "quick acting" or could be dispersed early in an encounter, undetected by chemical alarms, to cause slow, unnoticed degradation and followed with lethal agents.

c) Defeating decontamination. Decontamination of material depends on the ability to render a contaminating agent harmless or the ability to "wash away" such agent. There are several obvious approaches to defeating decontamination procedures. One might develop chemical agents which are impervious to strong oxidizing agents or agents which, when attacked by strong oxidizing agents, produced yet other lethal agents. Still another approach would be to add nearly intractable thickening substances to agents which were not only impervious to known U.S. decontaminating solutions, but also decomposed slowly to give very long-term release of lethal agents. At the same time that one develops these agents which are difficult to remove, one would attempt to develop decontamination methods which would deal with these new agents.

d) Developing biological agents (living organisms). Most threat living organisms have incubation periods which make them unusable for introduction in the heat of battle. However, disease-causing agents could be introduced prior to initiating hostilities in order to "soften-up" opposing troops. Diseases of choice would be those which were indigenous to the areas occupied so that there would be little possibility of detection of perpetration. Additionally, one could choose to develop drug resistant strains of those organisms and to develop innoculations for one's own troops.

e) Developing toxins. A decision to develop toxins might result from an impression that they were undetectable by U.S. systems and that some might provide order-of-magnitude lethality increases over chemical agents. However, weaponization of such high-potency agents might prove difficult while others could be readily produced and weaponized. Some are unstable over long time periods. Some would require subcutaneous introduction, making them appropriate for contaminating "fleshettes." Some would require ingestion, making them useful for surreptitious introduction into food or water supplies. Only a few would be appropriate for inhalation and percutaneous introduction. In any event, a vigorous research program could result in discovery of some military significant types. Many would be useful when employed against unprotected troops, a possibility which will be suggested later.

f) Directions for Tactical Uses of Chemical/Biological Weapons

The standard wisdom for use of chemical agents such as those listed in Table 1 is that nonpersistent agent is to be used in areas where one's own troops must pass and persistent agents are used for terrain denial. While there is some advantage to causing troops to don chemically protective ensembles so as to degrade their warfighting capabilities, the ultimate use of chemical/biological agents is to cause casualties directly. Therefore, given the assumed arsenal available to the Soviet Union, and several not-too-far-fetched predictions concerning new agents, one might consider the following possibilities for employment by their military planners.

1) Prior to initiation of hostilities, use disease organisms to debilitate military forces.

2) Use toxins and other poisons to make water supplies unusable.

3) Mix quick acting detectable agents with agents which are released or act over a long time period, choosing the slow-acting agents so that they are undetectable (e.g. toxins). Thus, when the detectable agents dissipate and troops assume that doffing protective ensembles is safe, the other agents can act on the now unprotected troops.

4) Always mix chemical rounds with conventional rounds. Then, no matter how little agent is present, enemy troops must always wear protective ensembles.

5) Use chemical agents/toxins/biologicals against which friendly troops have already been protected.

g) Directions for Technology

Aside from those already mentioned, several possibilities exist for the development of new technologies. One is encapsulation of agents in slowly deteriorating matrices which would degenerate or would undergo degeneration upon application of another substance or application of pressure.

Enhanced percutaneous penetration is another general approach which appears promising. If agents could be dissolved in a solvent which helped carry the agent through the charcoal layer and/or enhanced the speed of skin penetration of agent, a significant increase in effectiveness would be realized.

Anti-materiel agents are also possible. If air borne agents could be developed which would attack electrical insulation, lubricants, or some other essential aspect of warfighting machines, great tactical advantage would be realized.

Genetically engineered disease motes which were resistant to drug treatments but against which friendly troops had been vaccinated would also be of significant use. In fact, such possibilities are within reach of existing technologies.

Finally, an effort to develop dispersal technology could result in a significant increase in the effectiveness of existing agents, allowing them to be spread more evenly and more accurately.

In conclusion:

The U.S. bases its chemical/biological warfare policies on the ability to protect its troops against chemical/biological attack and the deterrent credibility posed by a twenty-year-old chemical weapons stockpile and no biological weapons stockpile whatsoever. The effectiveness of the U.S. chemical stockpile is constrained by its lack of immediate availability to U.S. commanders and accurate knowledge on the part of threat forces of its constituents. That knowledge allows threat forces to develop detection, protection, and decontamination materiel and doctrine based on an extremely limited range of agents. Even if the stockpile remains undeteriorated, the time which has elapsed since any change was made in stockpile constituents has probably allowed those involved in the Soviet research and development effort to discover and disseminate equipment which will protect the Soviet soldier against all fieldable U.S. chemical challenges. Thus, the deterrent effects of the stockpile are reduced immeasurably.

At the same time, the ability of the U.S. research and development community to respond to possible Soviet threats depends on knowledge of Soviet developments. If, as is suggested in this paper, the Soviets have continued research and development in the chemical/biological arena and they have directed that effort at defeating U.S. protective systems, then the chemical/biological battlefield will be an extremely hostile environment for the U.S. soldier. He will probably possess a mask and protective clothing that are ineffective, be unable to detect chemical/biological challenges, and be unable to decontaminate materiel or personnel when that is necessary. Additionally, if Soviet tacticians are at all creative in their use of both new and old chemical/biological weaponry, they will choose and develop situations wherein the weaponry will be brought to bear on unprotected troops.

In general, if the U.S. CBW policy is to succeed, the start made by the research and development community toward protecting U.S. soldiers must be maintained and intensified as must be the efforts by the intelligence community. New efforts to develop an effective CBW arsenal must also be initiated. In short, a more credible deterrence must be established.

F. THE IMPACT OF DEVELOPMENTS IN MOLECULAR BIOLOGY ON CHEMICAL WARFARE

CALVIN S. MCLAUGHLIN

Department of Biological Chemistry
University of California, Irvine
Irvine, California

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INTRODUCTION

The outline of a number of important scientific and technical advances that impact chemical warfare is now becoming clear. It is appropriate to reexamine current positions on chemical warfare in light of the technology that will probably become available over the next 10 to 15 years. Although the basic positions and assumptions about chemical warfare which were developed 40 or 50 years ago may still be satisfactory at the end of this technological revolution, it is appropriate to assess the implications of this technological revolution in chemical warfare to determine its impact on strategy, tactics and our basic positions.

The scientific revolution that impacts chemical warfare is centered in several disciplines. Advances in molecular biology and recombinant DNA technology now allow a new, rational and systematic approach towards increasing the toxicity of all existing chemical warfare agents. Agents are presently available and are being rapidly developed to increase the rate of drug and toxin penetration through the skin. Precision guided munitions that rely on advances in microelectronics have greatly increased the accuracy with which these toxic agents can be delivered. These developments may result in a substantial increase in the offensive capabilities of chemical warfare over the next decade.

At the same time, a number of these advances have the potential to strengthen defensive capabilities in chemical warfare. The advances in molecular biology, recombinant DNA technology and genetic engineering can be used in conjunction with developments in microelectronics and advanced analytical techniques to greatly enhance the detection and identification capabilities of chemical agents. The techniques of molecular biology should allow us to develop highly sophisticated treatments and antidotes to some of the most potent chemical warfare agents. The technology required to develop more effective protective devices for field armies appears to be in hand.

The scientific advances that have fueled this technological revolution have been developed independent of military implications. For example, the advances in molecular biology and recombinant DNA technology were supported by the National Science Foundation and the National Institutes of Health as a part of our national commitment to cure disease. The advances in analytical techniques are being supported by a combination of medical and environmental considerations. These rapid scientific advances will continue regardless of military decisions on chemical warfare. The results of this scientific revolution will continue to be published in the open literature and remain available to the world even though the scientific revolution is centered in the USA and Europe. Thus whether we like it or not we are in a sort of chemical arms race.

CHEMICAL AND CONVENTIONAL WARFARE

The nature of the tactics and strategy for chemical weapons should follow from a thorough discussion of their properties as offensive weapons and the defensive measure that can be taken against them. Such a thorough study based on the properties of the weapons and the defensive measures likely to be available at the end of this decade should be undertaken. However, in the absence of a definitive study relating strategy and tactics to the intrinsic properties of the weapons, it is still possible to make a few assumptions about their use that may hold true for at least the next decade.

1. Chemical weapons are unlikely to be used as strategic weapons unless a complete ban on nuclear weapons is in place and enforced.

Although VX, a nerve gas, is several times more effective on a weight basis at producing casualties than conventional high explosives, it is perhaps 1000 times less effective than nuclear weapons. However, some of the most potent toxins are about 100,000 times as potent on a weight basis as VX. This suggests that chemical warfare could be adapted to a strategic role in the absence of nuclear weapons. In the presence of nuclear weapons, there does not appear to be any clear cut advantage of chemical weapons compared to the highly developed and well understood nuclear weapons. Thus, in the absence of a ban on nuclear weapons, chemical weapons will not be used in a strategic mode.

2. In the presence of a full scale nuclear war, it is unlikely that either USSR's or the NATO's army will be able to undertake aggressive actions of more than a local nature.

It is possible that a nuclear war would remove all prohibitions from full scale chemical warfare that combatants have generally observed for a number of years, but it is unlikely that use of chemical warfare would be decisive under the conditions of such a broken back war.

3. In the absence of a nuclear war, a position of no first use of chemical weapons will be maintained by the USA.

This principle is a widely held moral position in this country. In the absence of catastrophic events such a long standing ethical position will only change slowly if at all.

On a practical level, the ethical and legal positions embodied in principle number 3 are reinforced by the position of tactical nuclear weapons in overall military strategy. Chemical weapons with the destructive power of nerve gases probably have an ecological niche in warfare that probably overlaps the roles assigned to tactical nuclear weapons. Chemical weapons would be most effective when used against concentrations of troops and equipment, fortified positions and airfields from the battle front to the rear lines back 100 or 200 miles from the front.

In the absence of a ban on nuclear weapons, the strategy for defending Europe from an attack by the USSR does not require and would probably not be enhanced by an offensive capability in chemical warfare. There may be one exception to this general statement. For reasons that will be discussed later, it is likely that the toxicity of persistent chemical warfare agents can be increased more than that of nonpersistent agents. Since NATO has an established defensive posture, it is possible that an effective non-nuclear defense of border regions could be developed based on persistent chemical weapons. If such a defensive posture would reduce the danger of a strategic nuclear exchange that would devastate the USA, USSR and Europe, it would be worthwhile. In the event of a conventional war in Europe the first few days are of critical importance. A limited offensive chemical capability for NATO would force the attacking USSR forces to operate in a chemical environment. This would slow their rate of advance and allow more time for NATO's mobilization.

4. In the absence of a requirement for offensive chemical warfare agents in this country's arsenal, there is a need to strengthen our defensive posture to handle several distinct situations.

The first situation would involve a massive offensive in Europe based on chemical warfare instead of tactical nuclear weapons. Such a strategy might be appealing to the USSR if it would cause NATO to withhold its tactical nuclear weapons out of fear of a strategic nuclear exchange. In this case, the attack would almost certainly involve several well studied chemical agents. Risking a major offensive with an experimental toxic agent is unlikely. Thus, intelligence sources should be able to identify the probable agents that would be deployed in substantial quantities. Our defensive capabilities should be directed to:

a. Detection of toxic agents as they are employed in an attack.

b. Deployment of protective equipment.

c. Decontamination procedures and effective treatment of the casualties.

The second situation concerns conflicts outside of Europe that would involve the major powers directly or through their allies in unconventional warfare situations. Examples of this type of action include the situations in Southeast Asia and Afghanistan where the USSR finds itself opposing unconventional forces. It may be anticipated that in addition to the conventional chemical warfare agents that would be utilized for a massive European offensive, other chemical agents would be used. These new agents would probably fall into two general classes -- persistent agents and harassing or riot control agents.

Persistent agents offer the technologically superior force, the advantage of an effective method of denying territory to opposing forces without stationing human resources in the area and making them vulnerable to attack. The lack of basic defensive measures makes the unconventional forces particularly vulnerable to chemical warfare.

This lack of basic protection devices also make unconventional forces vulnerable to the effects of riot control agents that are often not considered chemical agents. However, when used in conjunction with conventional warfare, they are likely to be effective. Their tactical use requires that they be closely supported by conventional arms because their incapacitating effects are typically of short duration.

When the technologically superior power is dealing with an unconventional enemy force in a strong defensive position, the use of chemical weapons offers a way to avoid the casualties that might result from hand to hand combat. By the same token it may be possible to develop protective gear for unconventional forces that will substantially reduce their vulnerability to chemical warfare without destroying their mobility.

New toxic agents are likely to be first introduced into the unconventional warfare arena. Chemical warfare agents are probably best used in combinations to make defense as difficult as possible. The effectiveness of any new agent or combination of agents would require testing in combat situations before they can be confidently added to a chemical warfare arsenal. In addition to the defensive needs outlined previously for European conflicts, a need exists to develop detection and identification capabilities for new toxins that may be introduced on an experimental basis in these areas.

Chemical warfare involving conventional armies should have the same characteristics as previously outlined for the European conflict whether the action occurs in the Middle East or elsewhere. The possible exception involves actions in the polar regions where low temperatures could affect the dispersal characteristics of some of the agents.

In conclusion, the main niche for highly toxic chemical agents is filled by tactical nuclear weapons. Our main interest in these weapons is defensive consistent with our position of no first use. We would be wise to maintain a usable stockpile of chemical weapons for their deterrent value within a strict no first use policy. This would raise the nuclear threshold and deter conventional war in Europe.

AGENTS

Chemical antipersonnel agents are divided into two broad groups, casualty agents and harassing agents. The harassing agents function as sensory irritants. They include low toxicity agents such as CS and CN employed in riot control. The casualty agents are divided into lung irritants, blood gases, vesicants, nerve gases, toxins and psychochemicals. This classification system was useful when developed, but does not indicate the underlying biochemical properties that make these agents toxic.

For many agents considerable information is available on their mechanism of action at the biochemical level. The general pattern that emerges in that the toxic compound eventually binds to and inactivates one or at most a few of the cell components that are essential for life. In all cases the critical cellular component is a protein molecule. There is a highly specific interaction between the toxin and an essential protein receptor molecule in the cell.

This pattern holds true for moderate toxicity agents such as the blood gas, hydrogen cyanide, which binds to the protein hemoglobin to prevent its use as an oxygen carrier. It is also true for the high toxicity agents such as the nerve gas VX which binds to the acetylcholine esterase protein and prevents its function as a critical component in neutral transmission. The very high toxicity toxins sometimes inactivate their target proteins catalytically; in this case each molecule of toxin is capable of inactivating a number of molecules of the cellular target protein. In any case, the basic pattern is that the toxin binds to cellular receptors as a key factor in the toxic reaction. A very wide range of toxins have been explored as potential chemical warfare agents.

As an example, a copy of Table 4.2 from the book "CB Weapons Today" is included. In all the cases that have been studied, this general pattern of receptor protein toxin interaction is a constant feature.

Table 4.2. Relative lethalities of selected natural and synthetic poisons: order-of-magnitude groupings relative to sarin

Synthetic poisons[a]	Relative lethality[b] (sarin = 1000)	Natural poisons[c]: Name	Source
	10^{-4} to 10^{-3}	Botulinal toxin type A, α-fraction[31]	Botulinal toxin type A
	10^{-3} to 10^{-2}	Botulinal toxin type A, crystalline[32]	*Clostridium botulinum* bacteria
		Tetanal toxin, crystalline[33]	*Clostridium tetani* bacteria
	10^{-2} to 10^{-1}; 10^{-1} to 1	Botulinal toxin type A, amorphous[31]	*Clostridium botulinum* bacteria
		Palytoxin[35]	*Palythoa* zoanthid coelenterates
Homocholine Tammelin-ester[1]	1 to 10	Batrachotoxin[36]	Kokói arrow poison
Dioxin[2]			
33 SN[1, 3]			
Ethylthioethyl-metasystox[1, 4]	10 to 10^2	Ricin, crystalline[37]	Castor beans, the seeds of *Ricinis communis*
Seleno-VE[5]		C-alkaloid E[38]	Calabash-curare arrow poison
HC-3[6]		Saxitoxin[39]	*Gonyaulax catanella* dinoflagellate marine algae
VX[7]		Tetrodotoxin[40]	Puffer-fishes and certain salamanders
Ro 3-0422[8]		Atelopidtoxin[41]	*Atelopus zeteki*, a Panamanian arrow-poison frog
TL 1236[9]		Abrin, crystalline[12]	Jequirity beans, the seeds of *Abrus precatorius*
Gd-42[10]		Indian Cobra neurotoxin[13]	Indian Cobra venom
DCMQ[11]		BWSV-toxin[11]	Black Widow Spider venom
Phospholine[12]			
3152 CT[13]			
Soman[14]			
(−)-Sarin[15]			
	10^2 to 10^3	Ricin, amorphous[15]	Castor beans, the seeds of *Ricinis communis*
		Kokói arrow-poison[16]	*Phyllobates aurotaenia*, a Columbian frog
		Russell's Viper venom[47]	*Vipera russelli*
		Israeli scorpion venom[48]	*Leiurus quinquestriatus*
		α-Aminitin[49]	The Death-Cap mushroom, *Amanita phalloides*
		Indian Cobra venom[50]	*Naja naja*
		Brown Widow Spider venom[51]	*Latrodectus geometricus*
		d-Tubocurarine[52]	Tube-curare arrow poison
Sarin[16]	1 000		
Tabun[17]	10^3 to 10^4	Aconitine[53]	Roots of Monk's-Hood, *Aconitum napellus*
Armin[18]		Physostigmine[54]	Calabar beans, the seeds of *Physostigma venenosum*
Gd-7[19]		North American scorpion venom[55]	*Centruroides sculpturatus*
Methyl fluoroacetate[20]		Strychnine[56]	*Strychnos nuxvomica* bark or seeds
		Black Widow Spider venom[57]	*Latrodectus mactans mactans*
		Ouabain[58]	*Strophanthus gratus* seeds
Hydrogen cyanide[21]	10^4 to 10^5	Nicotine[59]	*Nicotiana* tobacco plants
Cadmium oxide[22]		Western Diamondback rattlesnake venom[60]	*Crotalus atrox*
Mustard gas[23]			
Parathion[24]			
Lewisite[25]			
Phosgene[26]			
Arsine[27]			
Cyanogen chloride[28]	10^5 to 10^6	Bee venom[61]	[illegible]
Chlorine[29]			
White arsenic[30]			

Source: "The Problem of Chemical and Biological Warfare" Vol II, CB Weapons Today, Almquist & Wisell, 1973, p 290-291.

OFFENSE

It appears likely that the offensive capabilities of chemical warfare could be increased dramatically in effectiveness over the next decade. This increase would require a substantial development effort, but the required scientific knowledge is available. This research/development effort would only require a small percentage of the funds now devoted to the nuclear research/development effort.

Molecular biology has been applied to the design of important therapeutic drugs. A descriptive term for the procedure is molecular biomorphic analysis. The concept is simple. Isolate the receptor protein. Use the techniques of physical chemistry including X-ray diffraction to develop a complete structural description of the receptor-toxin binding. Ultimately, this will result in a three dimensional picture of the protein receptor-toxin complex. Chemical intuition will indicate which parts of the toxin are intimately involved in the binding to the protein receptor. This picture will suggest modifications in the toxin that will increase toxicity or maintain toxicity while creating more favorable physical properties such as increased or decreased persistence. A chemical warfare agent is termed persistent if it remains in the initial area for hours as contrasted to minutes.

To make these studies of receptor-toxin binding easier, large amount of the receptor could be isolated employing the techniques of genetic engineering to isolate the gene encoding the protein receptor. Each protein in the cell is constructed from a blueprint found in the cell's DNA. When this DNA blueprint from a human cell is transferred to another cell such as a bacteria, the bacteria will now make the human protein. Thus, large amounts of a specific human protein can be made utilizing commercial fermentation techniques.

The most potent toxins are proteins themselves. It is likely that their utilization as warfare agents can be greatly enhanced by molecular biology and genetic engineering. The first approach is to define the receptor protein-toxin protein binding as just described for small molecule toxins. Modifications to the toxin to increase stability and/or toxicity are made by isolating the gene containing the DNA sequence that is the blueprint for the toxin. This toxin gene can then be altered using genetic engineering techniques. These altered DNA's will give rise to altered toxin molecules that can be produced in bacteria. Again chemical intuition will suggest which alterations in the toxin molecules will increase toxicity or stability. When the desired toxin is achieved, it can be inexpensively produced in large quantities using genetic engineering techniques.

The other important development that may impact offense is the development of agents that greatly enhance the penetration of drugs through the outer layer of the skin. If the properties that allow this penetration can be built into the toxin molecule, then toxicity upon exposure of the skin will be substantially increased. In defense, suits are the weak point but in practice some minor leakage can be tolerated because most chemical warfare agents are substantially less toxic when only the skin is exposed compared to their toxicity when they are inhaled. Changes in the skin/inhalation toxicity parameter could be most important in changing the character of the chemical battlefield.

In conclusion, it should be possible to substantially increase, perhaps up to 1000 times, the toxicity of chemical warfare agents, while increasing their stability. These increases will occur more or less across the board but may be most dramatic in the case of the protein toxins which are persistent agents. The research funds required to accomplish these goals probably represent for the USSR only a small fraction of what is spent on nuclear matters.

It is important that some attempt be made to determine the impact of these very highly toxic agents on the battlefield. In principle the current protective technology is capable of defending against these toxins, but it is an open question whether the leakage rates are sufficient in practice to make this chemical battlefield totally uninhabitable.

DEFENSE

The same advances that have the potential for substantially improving the offensive capabilities of chemical weapons also offer the potential for substantial improvements in defense. While Table 4.2 is not complete, for example the trichothecene and aflatoxin mycotoxins are not included, a relatively complete list of potential chemical warfare agents can be assembled.

The procedures for enhancing the activity of toxic agents outlined under "Offense" serve to enhance existing agents not to discover new ones. Entirely new agents acting on new cellular receptors have to be discovered as chance byproducts of the chemical industry or through the description of new natural toxins. Undoubtedly, new toxins with completely new mechanisms of action will be discovered from time to time but their occurrence will be rare and their discovery would most likely be reported in the open literature. It should be a simple intelligence matter to survey the open literature for new potent toxic agents.

When the toxicity of a chemical warfare agent is increased by the means outlined, the basic mechanism of action and the cellular receptor protein is unchanged. The number of cellular toxin receptor proteins is substantially less than the number of toxins. For example, all the nerve gases act on one receptor protein - acetylcholine esterase. This makes defense an achievable goal because a defense must be developed and tailored to the specific receptors not the agents themselves. Thus, a good defense cannot be easily broken.

The defense requires several separate elements:

a. A detection capability.

Rapid detection is required because some of the more toxic agents cannot be detected by our sense of smell at their lethal concentrations. In a tactical situation many troops may be aware that chemical munitions are being used because they have a distinctive sound and appearance as they explode when compared to conventional high explosive munitions. However when conventional and chemical munitions are used together and when visibility is poor a detection system is required to detect the presence of toxic agents. Even under favorable circumstances when a detection system is not required to detect the presence of a toxic agent, it is required to determine the nature of the agent and when it is safe to remove protective gear. The detection system should be rapid, sensitive and accurate in the range of biologically effective toxic concentrations. It should identify the receptor - toxin system involved so that the specific antidotes can be administered. Finally it should be automatic.

b. Protective devices

The principles behind the available protective gear are sound. The basic approach is to remove the toxic agents from the air for breathing, while preventing dermal exposure by suits or shelters that are impermeable to the agent. The field vehicles used in a mobile war can be made into effective shelters. The gas masks can be effective against the highly toxic protein toxins since they and other non-volatile small molecule toxins must be dispersed as aerosols. This is not to say that in practice there are no problems. The suits and masks are cumbersome and at temperatures above 50 degrees, they can only be worn for limited periods of time. They may tear and require repair on the battlefield. Nevertheless, in principle it is possible using existing technology to design masks, suits and shelters that are capable of resisting the known toxic agents and that can resist any new toxin that can be developed. However in an actual battlefield situation leakage may compromise the safety of a suit challenged by toxic agents much more toxic than nerve gases. This problem needs to be carefully evaluated.

c. Treatment procedures for the casualties and decontamination procedures.

The treatment for the casualties needs to be tailored to the toxic agents. For some of the toxic agents, there are specific antidotes or specific treatments. The decontamination procedures also need to be tailored to the specific agents.

Molecular biology and genetic engineering have the potential to make a unique contribution to the defense. It is possible to isolate the gene that carries the DNA blueprint for the cellular receptor protein for each toxin class. For nerve gases, one would isolate the gene for the human acetylcholine esterase protein. Using this DNA, large amounts of the receptor protein can be isolated. This receptor protein binds toxin as an essential part of the toxin's mechanism of action. It may be possible to make an antibody that will also bind the toxin. Probably a monoclonal antibody would be used. Either the receptor protein or the specific antibody can then be used to determine the presence and identity of the toxin and quantify the amount of toxin present. Biochemical methods called radioimmunoassays, RIA, and ELISA, enzyme linked immunoassays, are available that use the ability of these proteins to bind the toxin to identify and quantitate the amount of toxin available. These methods represent a substantial potential advance over older detection methods in terms of speed, accuracy and sensitivity. However, to take full advantage of the potential improvements, these advances in receptor technology and immunology should be integrated with advanced concepts in analytical chemistry and microelectronics to develop very rapid, sensitive and specific detection methods which have the potential for being automatic. There are several appealing choices for these integrated devices.

One such integrated device involves incorporating the binding proteins into electrochemical devices such as membrane electrode essays and dielectrometers. Spectophotometric methods which utilize optical wave guides incorporating bound receptor proteins offer great sensitivity in the measurement of changes in either the conformation of the binding protein or the displacement of prebound toxin molecules. Perhaps the most exciting possibility is the incorporation of receptor proteins directly into semiconductor devices. Binding the toxin would change the conductivity of these devices. All these approaches offer the potential of speed, accuracy and specificity far surpassing what is now available. Most importantly, they can be directly tied to microprocessors for computer analysis of the data. These advances should allow the development of fieldable automatic alarm systems. Systems based on the sensitivity of mass spectrophotometry such as GC-MS and MS-MS have near term advantages because their integration into microprocessors for computer analysis of the data is more developed. They are subject to countermeasures and may not be effective against the very toxic protein toxins. These devides can be employed in conjunction with optical devices such as LIDAR which have the potential for remote sensing of toxic agents but are subject to countermeasures. Detection and identification are the keys to a successful defense.

Improvements in the protective equipment are essentially a matter of implementing the continuous improvements in such equipment produced by conventional technology for commercial purposes. The protective equipment must be tested to determine that it offers adequate protection against each new agent deployed in quantity by the USSR. Effective use of the protective equipment depends on the earliest possible warning of a chemical attack.

The effective treatment of casualties depends on understanding detail the mechanism of action of the toxin. Advances in molecular biology and biochemistry make this an achievable goal for any toxin. A specific treatment can then be rationally developed for each toxin. In many cases, it may be possible to develop specific antidotes which will enhance the survival of human resources exposed to the toxin during the attack. It is not necessary for the army to undertake detailed studies on the mechanism of action of each toxin class. Many of the bacterial toxins are being thoroughly investigated as human health hazards by the National Institutes of Health. The results of their studies will be directly applicable. Effective treatments and antidotes are already available for nerve gases. It appears sound to restrict the determination of the mechanism of action and the development of a rational therapy for agents deployed in quantity by the USSR. Even with the full range of modern technology, improvements in therapy will be substantially more costly than improvements in detection. Clearly these efforts in therapy must focus on the major toxins deployed or potentially deployed by the USSR. Fortunately, in the case of toxic agents general supportive therapy is helpful even when a specific therapy is not available. However in a major battle situation, supportive therapy places great demands on the medical service. If the number of casualties is substantial, the medical service will not be able to provide supportive therapy for more than a small percentage.

CONCLUSION

1. Chemical warfare agents and tactical nuclear weapons can fulfill the same mission requirements.

2. Consistent with our national policy of no first use of chemical weapons and our reliance on nuclear weapons to defend Europe, research to strengthen the offensive use of chemical weapons is not required.

3. Recent scientific advances indicate that the defense against chemical agents can be strengthened in two critical areas: the development of specific, sensitive detection systems for chemical agents and the development of specific therapies for the major toxins in the USSR's arsenal.

4. The defense should be strengthened in both detection and treatment. However, an improved detection system coupled with improvements in the protected gear is far more cost effective than treating casualties. Again, an ounce of prevention will prove worthy of a pound of cure.

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